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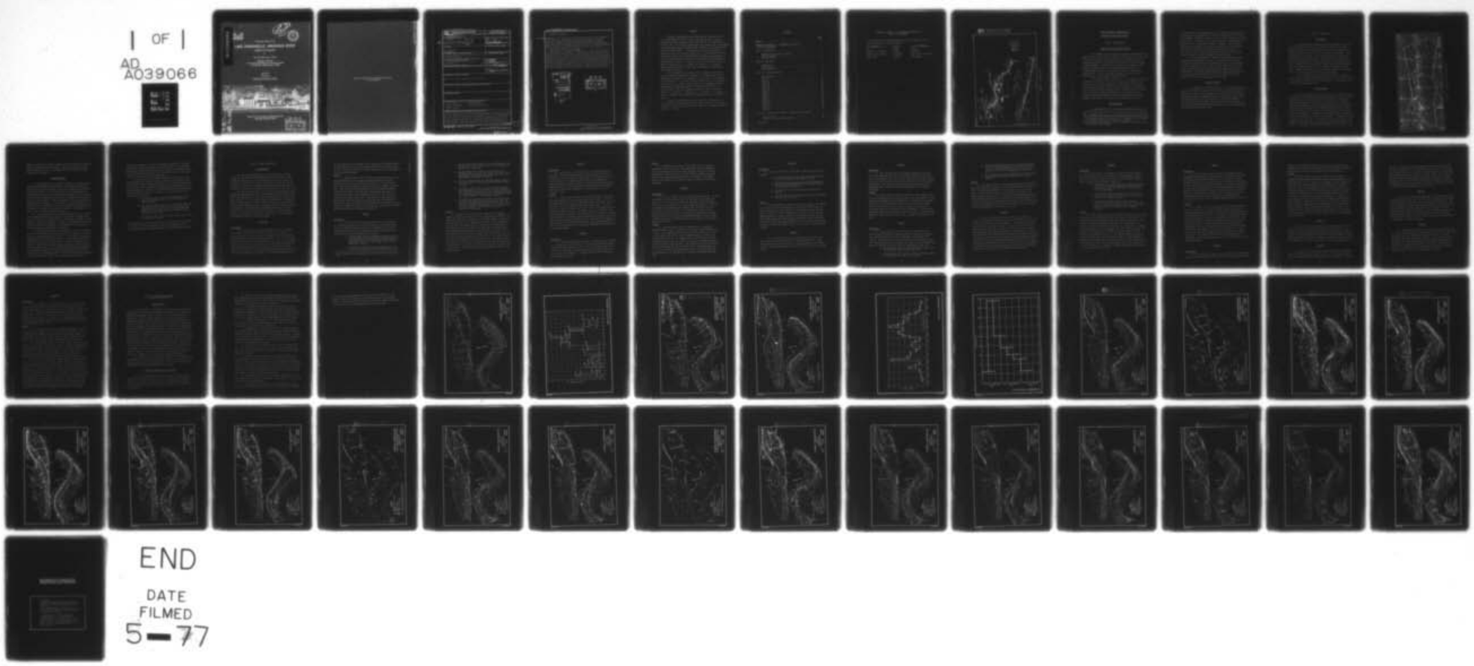

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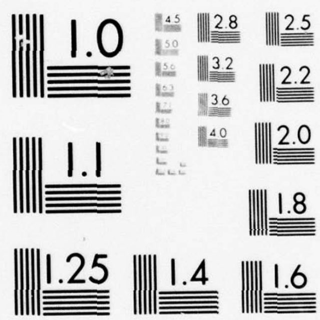

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TECHNICAL REPORT H-77-4

LAKE DARDANELLE, ARKANSAS RIVER

Hydraulic Model Investigation

by

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Hydraulics Laboratory
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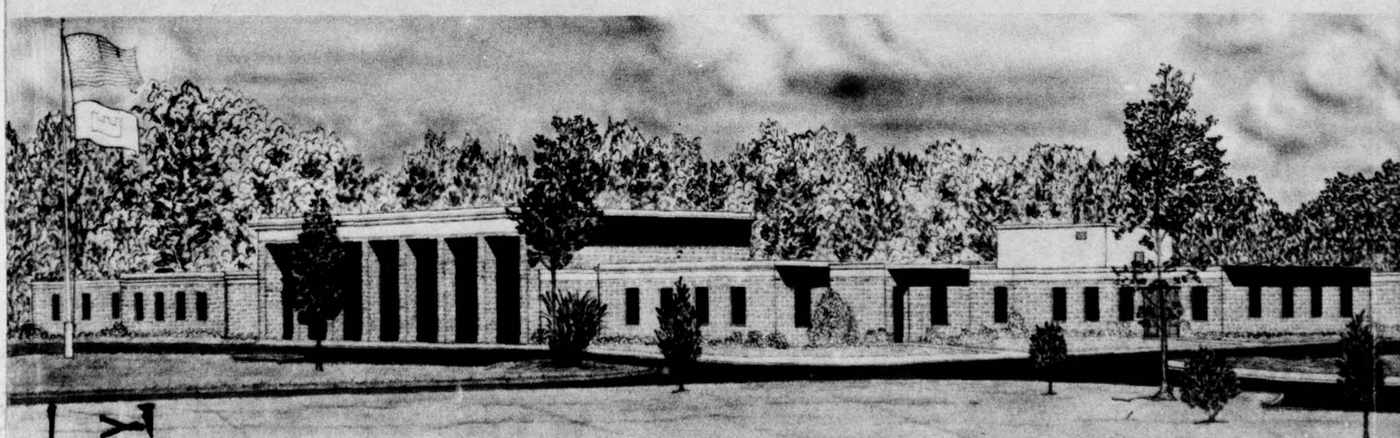
March 1977

Final Report



Prepared for U. S. Army Engineer District, Little Rock
Little Rock, Arkansas 72203

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20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

Lake Dardanelle is a 51-mile-long reservoir formed by Dardanelle Lock and Dam which is located at mile 205.5 on the Arkansas River. The lake was designed to provide head for power, depth for navigation, and a trap for a considerable volume of sediment. The river was realigned and stabilized in the portion of the lake upstream of mile 238.4 with plans for progressive improvement of the reach downstream as deposition and channel development indicated the need for such improvements. Water was impounded in 1964; and by 1972, deposition had → next page
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20. ABSTRACT (Continued).

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accumulated in the vicinity of Horse Head Creek such that it was beginning to hinder navigation. This study was conducted to determine the type and location of training and stabilization structures needed to develop a satisfactory navigation channel downstream of mile 238.4 and to provide a satisfactory channel approaching the navigation span of the proposed highway bridge at mile 234.9. A movable-bed model reproduced the reach of the Arkansas River and adjacent overbank area from mile 238.5 to 231.3 to scales of 1:120 horizontally and 1:80 vertically.

Results of this investigation indicated that: a plan could be developed that would provide a satisfactory crossing toward the left bank and in the approaches to the proposed bridge. Navigation gaps could be used in the two closure dikes across the channel along the right bank during construction and development of the crossing. Some shoaling could be expected in the upstream approaches to the gaps and some scouring could be expected just downstream of the gaps. Development of a channel along the left bank upstream of the proposed bridge would reduce the tendency for erosion of the left bank in the upper portion of the bend downstream of the bridge. Permitting a portion of the left bank near the lower end of the bend below the bridge to erode would tend to improve the alignment of the channel over the crossing toward the right bank.

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PREFACE

The model investigation reported herein was conducted for the U. S. Army Engineer District, Little Rock (SWL) by the U. S. Army Engineer Waterways Experiment Station (WES) during the period May 1973 to April 1975. The study was authorized by the Office, Chief of Engineers, in 4th Indorsement dated 9 November 1972 to letter of 20 September 1972 from SWL to WES, subject: Proposed Model Study of Lake Dardanelle. During the course of the model study, the U. S. Army Engineer Division, Southwestern (SWD), and the SWL were kept informed of the progress of the study through monthly progress reports and periodic transmittal of preliminary test results. In addition, Mr. Tasso Schmidgall, SWD, and Messrs. Jack Woolfolk, O. B. Yeager, Joe Clements, D. G. Bratton, David Meadows, and James Tollett, SWL, visited WES to observe tests and discuss test results.

The investigation was conducted in the Hydraulics Laboratory under the general supervision of Messrs. H. B. Simmons, Chief of the Hydraulics Laboratory; F. A. Herrmann, Assistant Chief of the Hydraulics Laboratory; J. J. Franco (retired), former Chief of the Waterways Division; and J. E. Glover, present Chief of the Waterways Division. The engineer in immediate charge of the model study was Mr. J. E. Foster, Chief of the River Regulation Branch. He was assisted by Messrs. P. G. Combs, S. T. Mattingly, J. A. Holliday, H. S. Headley II, and V. E. Stewart. This report was prepared by Messrs. Foster and Franco.

Directors of WES during the course of this investigation and the preparation and publication of this report were BG E. D. Peixotto, CE, COL G. H. Hilt, CE, and COL John L. Cannon, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
miles (U. S. statute)	1.609344	kilometres
cubic feet per second	0.02831685	cubic metres per second
cubic yards	0.7645549	cubic metres

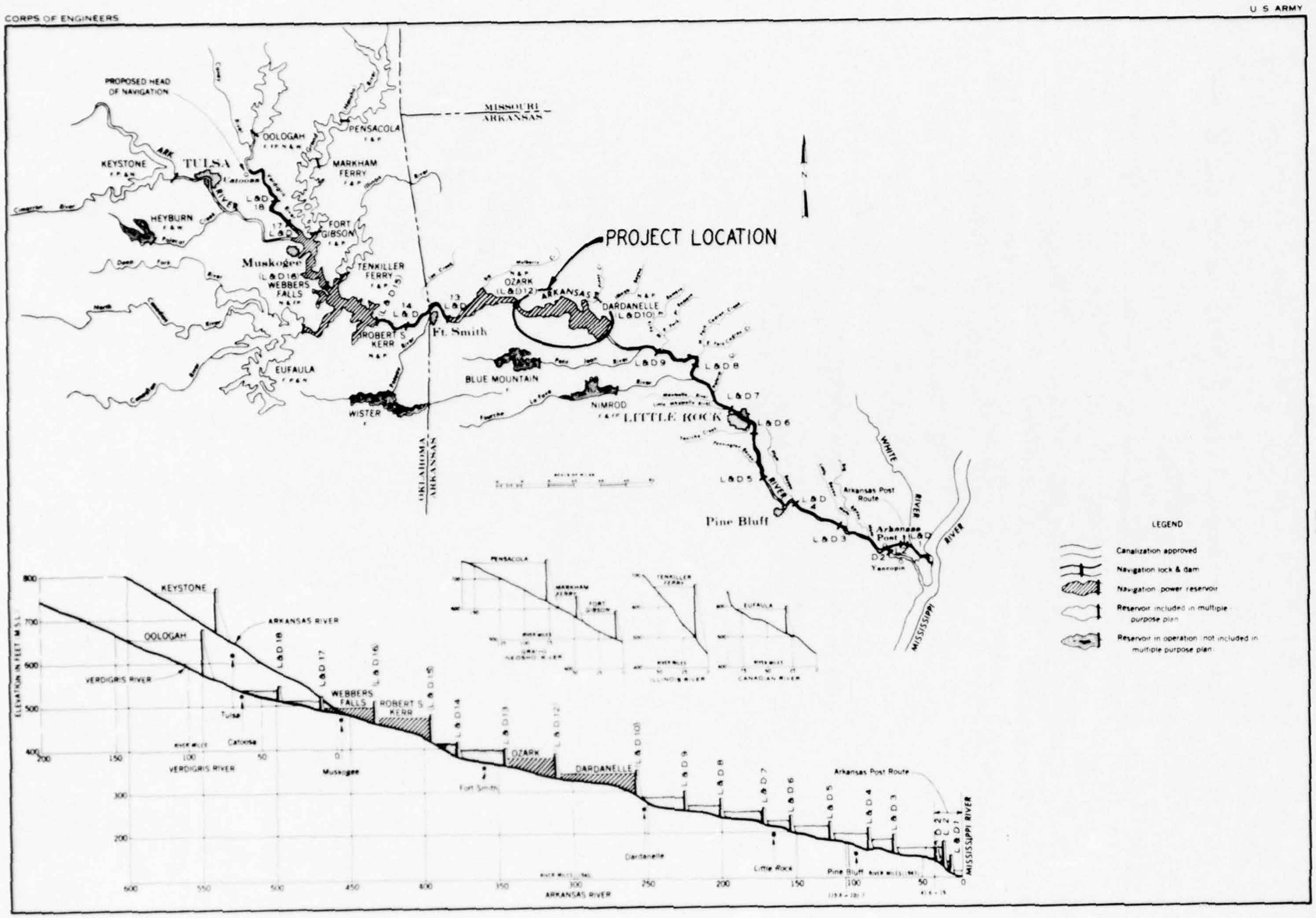

Figure 1. Vicinity map

LAKE DARDANELLE, ARKANSAS RIVER

Hydraulic Model Investigation

PART I: INTRODUCTION

Arkansas River Navigation System

1. The Arkansas River navigation system was authorized by the Congress of the United States in Rivers and Harbors Act of 24 July 1946. This system provided for the development of the Arkansas River for navigation, additional flood control, hydroelectric power generation, and other purposes. Construction of the project was begun in 1957. Navigation reached Little Rock in December 1968, Fort Smith in December 1969, and the Port of Catoosa, the head of navigation, in December 1970. In 1971, Congress designated the project as the McClellan-Kerr Arkansas River Navigation System.

2. The system (Figure 1) consists of: (a) seven large upstream reservoirs that provide flood control storage, trap sediment, and supply water for power, navigation, and other uses; (b) four high-lift locks and dams that provide depth for navigation, provide head for power, and trap some sediment; and (c) thirteen low-lift locks and dams that provide minimum 9-ft* depths for the remainder of the 448-mile navigation channel from the Mississippi River to Catoosa, Oklahoma (near Tulsa). The total lift for the system is 420 ft.

Lake Dardanelle

3. Lake Dardanelle is a 51-mile-long reservoir formed by Dardanelle Lock and Dam, one of the four high-lift structures in the system. Dardanelle Dam is located on the Arkansas River at mile 205.5,**

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

** All mileage cited herein refers to navigation mile except in Figure 1 which is 1940 mileage.

2 miles upstream from Dardanelle and 3 miles southwest of Russellville. The earth-fill and concrete dam is 2683 ft long and rises 68 ft above the streambed. Dardanelle Lock has a 100- by 600-ft chamber and a normal lift of 54 ft. In addition to its other purposes, Lake Dardanelle was designed to trap a considerable volume of sediment. The river was stabilized and realigned in the upper 40 percent of the lake (down to mile 238.4). The bank stabilization and channel rectification structures were not continued downstream of this point because they were not needed to initiate navigation on the waterway.

4. With the impoundment of water in Lake Dardanelle in 1964, anticipated sedimentation occurred. By 1972, when this study was authorized, the deposition had accumulated such that it was beginning to hinder navigation in the vicinity of Horse Head Creek, just downstream from where the bank stabilization and channel rectification works ended. The Arkansas Highway Department proposed construction of a bridge across Lake Dardanelle at mile 234.9 with the tentative location of the navigation span near the left bank.

Purpose of Study

5. The purpose of the model study was to determine the type and location of control structures needed to develop a stable navigation channel with a satisfactory alignment in the vicinity of the proposed bridge and to make Lake Dardanelle an efficient sediment trap. Since the Arkansas River is open to navigation, it was also necessary to develop a construction sequence that would permit the development of a satisfactory channel along the new alignment and at the same time maintain navigation through the reach.

PART II: THE MODEL

Description

6. The model of Lake Dardanelle, which reproduced the reach of the Arkansas River from mile 231.3 to 238.5 (Figure 2), was built to linear scale ratios of 1:120 horizontally and 1:80 vertically which produced a slope scale ratio of 1.5 to 1, model to prototype. A small supplementary slope needed to provide satisfactory bed movement was incorporated in the model design. The model was of the movable-bed type with fixed-banks and overbank areas molded in sand-cement mortar. The bed material was coal which had a median grain diameter of about 4 mm and a specific gravity of 1.30. Dikes were molded of crushed stone. Folded strips of mesh wire were used to simulate the roughness effect of trees and underbrush on the overbank areas.

7. The overbank portion of the model was molded to contours shown on USGS quadrangle maps dated 1961 and 1962. The initial contours of the movable-bed channel portion were molded to a survey made during the period October-December 1971.

Appurtenances

8. Water was supplied to the model by a 10-cfs axial flow pump operating in a circulating system and was measured at the upper end of the model by two venturi meters of different sizes to provide for accurate measurement over the range of discharges to be reproduced. Water-surface elevations along the channel were measured by 12 piezometers which were connected to a centrally located gage pit. Water-surface elevations at the lower end of the model were controlled with an adjustable tailgate. A graduated container was used to measure bed material introduced at the upper end of the model. A sediment trap was provided at the lower end of the model where extruded material could accumulate and be measured to determine the amount discharged for any period. A carefully graded rail was installed along each side of the

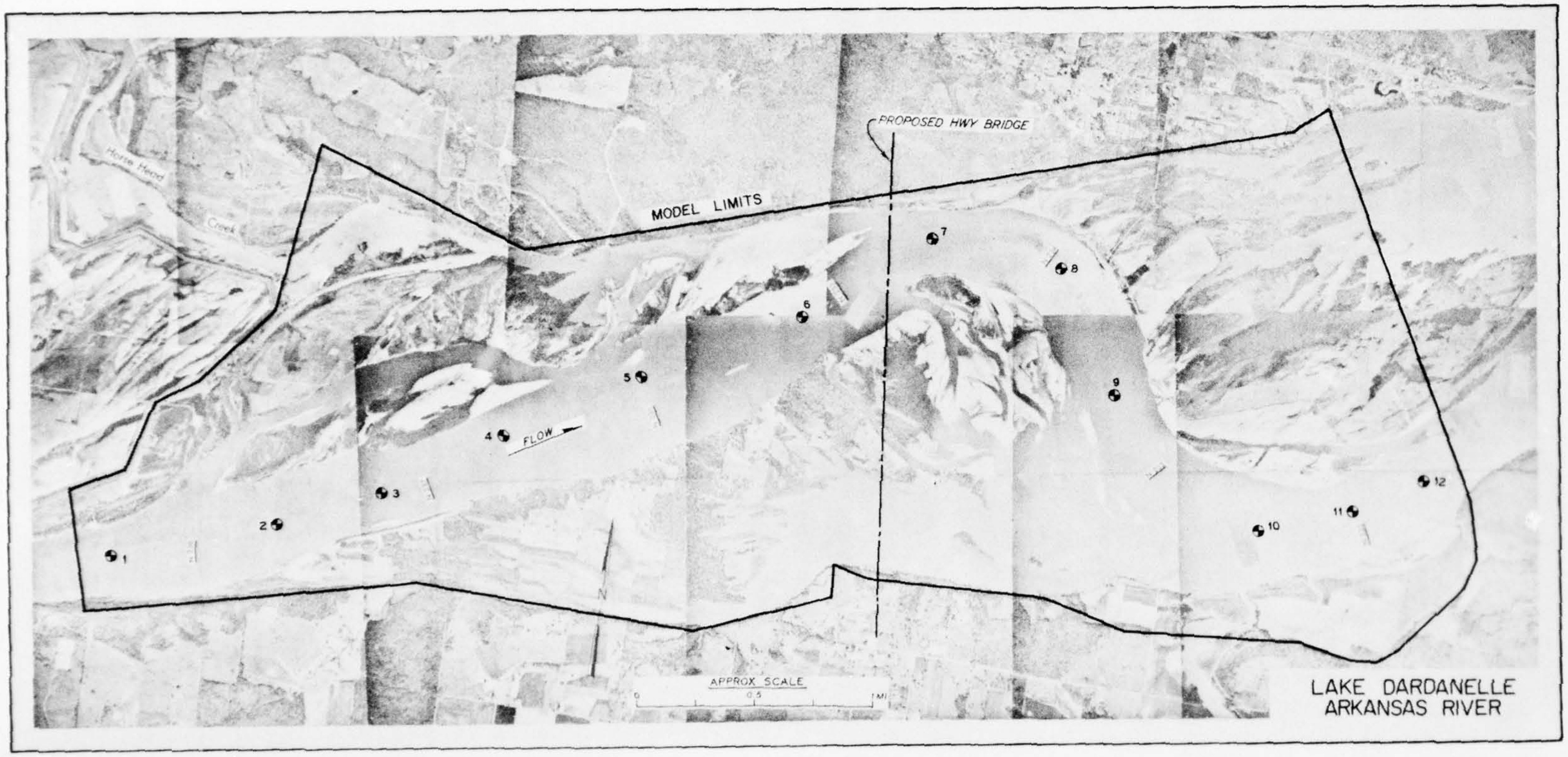

Figure 2. Model layout and gage location

channel to support sheet metal templates used for molding the model bed prior to initiation of certain tests. These rails were also used to provide vertical control for surveying the model bed and to install structures in the model.

Model Adjustment

9. The reliability of a movable-bed model to reproduce channel developments generally representative of those expected in the test reach of the river under similar conditions is established through the verification process. This process involves the adjustment of the various hydraulic forces, model-operating techniques, and other factors until the model demonstrates its ability to reproduce with acceptable accuracy certain changes in channel configuration that are known to have occurred in the prototype. In this manner, the model-operating techniques; the time, discharge, and bed-load movement scale relations; and the degree of accuracy to be expected of the model are determined for use in tests of various plans of improvement.

10. The adjustment of this model was complicated by the reservoir which affected water-surface slopes and bed movement, dredging operations and location of dredged material, bank caving, islands, shifting sandbars, and many side channels. Because of the complex nature of the reach, an unusually large number of adjustment tests were required to obtain satisfactory verification of the model.

11. The adjustment tests were started with the bed of the model and active caving banks molded to the conditions indicated by the river survey of November-December 1971 (Plate 1). The model was operated by reproducing the flow hydrograph (Plate 2) which occurred in the river between the time of the 1971 survey and the survey of October 1973 (Plate 3). During the adjustment tests, progressive changes were made in the discharge scale, rate of introducing bed material, and methods of reproducing dredging operations and bank caving until the model reproduced with a reasonable degree of accuracy the conditions indicated by the river survey of October 1973. Between December 1971 and

October 1973 there were at least five dredging operations in the reach involving the removal and placement of some 250,000 cu yd of material. In addition, considerable bank caving had occurred, particularly along the left bank between miles 234.5 and 233.6 with the bank at that point receding as much as 400 ft during the period.

12. Verification of the model was based on the results of the final adjustment test shown in Plate 4, compared with conditions indicated by the October 1973 prototype survey. This comparison shows that the essential trends and channel configurations were reproduced with a reasonable degree of accuracy. The principal differences between model and prototype which have to be considered in the evaluation of test results were as follows:

- a. The channel along the right bank between miles 236.8 and 234.6 was not as wide as that indicated by the prototype survey.
- b. The narrow channel at the head of the island toward the left bank did not develop as in the river, and the channel along the right side of the island was somewhat wider in the upper reach and shallower near the lower end of the island.
- c. The depth of scour along the caving bank at mile 233.6 was deeper in the model.

These differences could have been caused to some extent by the method of reproducing dredging operations, shape and erodibility of the islands and sandbars, and method and rate of reproducing bank caving.

PART III: TESTS AND RESULTS

Test Procedure

13. Tests were concerned with the development of a stable channel of good alignment and adequate depth for navigation. Plans tested were designed to shift the channel toward the left bank just upstream of the head of the island at mile 235.6 and at the same time to provide a satisfactory channel approaching the navigation span upstream and downstream of the proposed highway bridge at about mile 234.8.

14. The model was operated for all tests by reproducing a flow hydrograph submitted by the U. S. Army Engineer District, Little Rock (SWL), as being typical of what could be expected in this reach of the river (Plate 5). Two of the plans were also tested with a rapid-rise flood of short duration as shown in Plate 6, and one of the plans was tested by reproducing the typical hydrograph with the discharge reduced by 50 percent. The water-surface elevations during the tests were controlled at the lower end of the model based on a stage-discharge rating curve furnished by the SWL for that location. The channel bed was surveyed at the end of each hydrograph.

Base Test

Description

15. A base test was conducted to determine the developments that could be expected in the reach before any of the training structures would be constructed and to provide a basis for comparing the effectiveness of proposed improvement plans. The test was started with the same conditions as those obtained at the end of the verification test except for the installation of the stone-fill revetments on the right bank between miles 237.1 and 236.8 and on the left bank between miles 236.2 and 235.5 which were under construction at the time the study was undertaken. The tops of the revetments were placed at

el 343.* Except for the removal of the island along the channel side of the revetment at mile 235.8, no dredging was done in the model during the test. Results of the base test were developed with one reproduction of the typical hydrograph.

Results

16. Results shown in Plate 7 indicate little difference in the trends developed with the typical hydrograph compared with those obtained by the end of the verification (Plate 4). The main channel would tend to remain along the right bank with some tendency for shoaling to less than project depth along the proposed channel alignment toward the left bank. There was some scouring near the head of the island to the right of the revetment at mile 235.8. The crossing toward the left bank at mile 234.5 would produce a rather sharp bend and would increase the attack on the left bank and the tendency for bank caving. There was little natural tendency for the channel to cross toward the revetment at mile 235.8, although the channel along the left bank downstream of the revetment was maintained.

Plan A

Description

17. Plan A is the original plan proposed for the development of a navigable channel with a crossing toward the left bank at about mile 236. This plan (shown in Plate 8) was developed in a series of preliminary tests based on observations of currents and trends with representative flows and included the following:

a. A longitudinal rock dike forming the concave side of a bend extending from the right bank at mile 236.8 to mile 236.0 with three baffle dikes extending from the longitudinal dike to the right bank. Crest of the dikes was at el 343.

b. A closure dike extending from the right bank to the head of the island at mile 235.7 with crest at el 339.

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* All elevations (el) cited herein are in feet referred to mean sea level.

c. Two short spur dikes located on the shelf along the right bank at miles 237.9 and 237.6 with crest elevations of 345 and 341, respectively.

d. Two spur dikes located along the right side of the islands at miles 237.0 and 237.2 with crests at el 341. The minimum clear channel width between the ends of the dikes and the right bank was 1000 ft.

e. A dike was placed across the secondary channel between the island at mile 236.9 and the left bank with a crest at el 341.

f. A dredge cut 250 ft wide to el 324 was made toward the left bank extending from mile 236.7 to 234.9 following the longitudinal dike along the right bank and the stone-fill revetment along the left bank. The dredged material was placed landward of the dikes and revetment.

g. A trench-fill revetment was simulated in the bend along the left bank between miles 235.3 and 233.2 along an alignment furnished by the Little Rock District. The top of the revetment was placed at el 343, and the existing bank riverward of the revetment was molded to simulate a caving bank.

Results

18. Results of tests of this plan showed that the dredged channel had shoaled as much as 6 or 7 ft along the upper reach of the longitudinal dike with a tendency for the deeper channel to form away from the dike (Plate 9). Downstream of the end of the longitudinal dike (mile 236) the dredged channel shoaled; but a deeper channel developed along the right side of the dredge cut and adequate depths were maintained from that point to the left bank. There was some shoaling along and in front of the stone-fill revetment along the left side of the channel between miles 236 and 235.4. The channel along the left bank in the bend at mile 234 shoaled to less than project depth; this shoaling was caused by dispersion of flow to the right downstream of the island. The left bank in the bend was allowed to erode to the revetment line. The crossing toward the right bank at about mile 233 was maintained.

Plan A-1

Description

19. Plan A-1 was a modification of plan A and involved the shortening of the upper dike along the island at mile 237.2 and the installation of a dike along the right side of the island at mile 236.7 to el 339 (Plate 8). A channel width of 1200 ft was maintained between the dikes along the islands and between the right bank and the longitudinal dike. The channel along the longitudinal dike extending toward the left bank was redredged to a 250-ft width at a bottom elevation of 324.

Results

20. Results given in Plate 10 show that a channel of adequate depth had developed in the crossing toward the left bank. Scour holes had formed near the lower end of the longitudinal dike (mile 236) and at the upper end of the stone-fill revetment at mile 236.2. The shoal along the stone-fill revetment on the left side of the channel had been scoured and reduced in size. The channel along the left bank in the bend between miles 234.4 and 233.5 was narrow, but a channel of adequate width and depth for navigation had developed across the point more than 1000 ft from the bank at about mile 233.8. Because of the alignment of this channel, the crossing toward the right bank downstream (mile 232.5) moved to the left some 1700 ft, indicating some bank caving downstream of the revetted bank.

Plan A-2

Description

21. Plan A-2 was the same as plan A-1 except that the revetment on the right bank from mile 237.1 to 236.8 and the proposed revetment along the left bank from mile 235.3 to 233.0 were raised from el 343 to 347 and a spur dike was installed on the left bank at mile 236.3 with top at el 337 (Plate 8). A minimum width of 1200 ft was maintained between the dikes.

Results

22. Modifications of plan A-2 had little effect on channel developments within the reach. The sandbar that extended downstream past the upstream end of the left bank revetment at mile 235.8 moved downstream to about mile 235.5. The deep channel remained away from the left bank revetment throughout most of its length. The sandbar along the left bank in the vicinity of mile 234 increased in size and elevation.

Plan A-3

Description

23. Plan A-3 (Plate 8) was the same as plan A-2 except: (a) the spur dike on the left bank at mile 236.3 was raised on the bank end from el 337 to 341; (b) a spur dike was installed on the left bank at mile 236.2 to an elevation of 341 at the bank and sloping to el 337 at the channel end, leaving a clear channel width of 1200 ft; (c) the left half of the closure dike on the right bank at mile 235.7 was raised from el 339 to 341; (d) a spur dike was installed on the right bank at mile 234.2 to el 339 at the bank and sloping to el 337 at the channel end; and (e) a 250-ft-wide channel was dredged to el 324 from mile 234.4 to 233.5.

Results

24. Results shown in Plate 11 indicate that a reasonably adequate channel would be maintained in the upper reach from mile 238.5 to 233.7. The sandbar riverward of the revetment along the left side of the channel, mile 236.2 to 235.6, remained about the same as that obtained with plan A-2. The sandbar along the left bank in the bend downstream of mile 234.5 was reduced in size, but an adequate channel was not developed along the bank. Flow through this reach was divided. The crossing toward the right bank (mile 232.5) had moved farther to the left, indicating bank caving downstream of the revetted bank and an improvement in the alignment of the channel approaching the right bank.

Plan A-4

Description

25. Plan A-4 (Plate 8) was the same as plan A-3 except for the following:

- a. A 700-ft-long vane dike was installed along the right side of the channel at mile 235.8 to el 339.
- b. Two 1000-ft-long vane dikes were installed along the right side of the channel at miles 234.6 and 234.4 to el 339 and 337, respectively.
- c. The spur dike on the right bank at mile 234.2 was removed.
- d. A 250-ft-wide channel with bottom at el 324 was dredged from mile 234.5 to 233.4.

Results

26. Results given in Plate 12 show little change in the channel from the upper end of the model reach to about mile 234.6 except for some increase in the width and depth of the channel opposite the vane dike at mile 235.8. In the reach below the location of the proposed highway bridge, the channel along the left bank had deepened and adequate channel depth and width extended downstream to about mile 234.1. The center channel had shoaled downstream of that point and the channel along the left bank had improved some, but the width of the channel was limited.

Plan A-5

27. Plan A-5 was the same as plan A-4 except that the vane dike at mile 234.4 was extended 120 ft downstream (Plate 8). This modification produced little change in the development of the channel along the left bank between miles 234.0 and 233.6, which was of limited width.

Plan A-6

Description

28. Plan A-6 (Plate 8) was the same as plan A-5 except for a 950-ft-long vane dike with top el of 337 that was added on the right side of the channel at mile 234.0 and two spur dikes that were installed on the right bank at miles 234.0 and 233.8 with top el of 340 and 339, respectively. This plan was also tested with the fast-rising flood hydrograph shown in Plate 6 after the reproduction of the typical hydrograph.

Results

29. Results shown in Plate 13 indicate that an adequate channel would be developed along the left bank and in the lower approach to the proposed new highway bridge navigation span. The width of the channel along the left bank below mile 234.0 was not as wide as the channel through the reach upstream but could be expected to improve with deposition along the right bank which was increasing. The fast-rising hydrograph reproduced on the model at the end of the test produced some decrease in depths but had little effect on channel developments in the reach.

Plan B

Description

30. Plan B was based on the results of tests of plan A as modified and was designed to determine the best sequence of construction that would produce the least interference with normal river traffic. The model for this test was restored to the conditions that were obtained at the end of the base test except for the following which might be included in the first phase of construction (Plate 14):

a. The revetment along the right bank between miles 237.1 and 236.8 was raised from el 343 to 347.

b. A closure dike with top at el 341 was installed between the island and left bank at mile 236.9.

c. Two closure dikes with crest at el 338 were installed across the existing channel at miles 235.7 and 235.0 except for a 250-ft-wide navigation gap with a bottom elevation of 327 near the right bank of each dike.

d. The left bank in the bend between miles 233.8 and 232.7 was restored to existing conditions with erodible material.

Results

31. The channel along the right bank approaching the navigation gap in the upper dike shoaled to less than project depth (Plate 15). A scour hole developed downstream of the gaps in both of the closure dikes. Scouring below the upper dike resulted in shoaling of the channel between the two dikes. A channel of adequate depth and limited width developed toward the left bank through the opening between the stone-fill revetment and the island along the ends of the closure dikes. A shoal area developed along the left bank at mile 234 but an adequate channel was maintained to the right of the shoal.

Plan B-1

32. Plan B-1 involved the next step in the construction sequence and provided for the closure of the navigation gap in each of the two dikes across the existing channel. This change increased the tendency for the channel to develop in the crossing toward the left bank upstream of the dikes. By the end of the test of this plan, an adequate channel had developed downstream to about mile 234.3 (below the location for the proposed bridge); however, the channel downstream of this point was affected by the sediment moved from upstream and the dispersion of flow to the right downstream of the island. The shoal area along the left bank near mile 234 increased in size and elevation; and another shoal area developed along the right side of the channel, reducing the width of the navigable channel to about 200 ft.

Plan B-2

Description

33. Plan B-2 was a continuation of the construction sequence with the initiation of the construction of the longitudinal dike of plan A along the right bank at mile 236.8. This plan was the same as plan B-1 except for the following (Plate 14):

<u>a</u>. Construction of a longitudinal dike between miles 236.8 to 236.6 to el 343 and construction of the first two spur dikes at miles 236.6 and 236.3 to el 343.0 and 340.0, respectively.

<u>b</u>. Construction of three spur dikes along the left bank at miles 234.1, 234.0, and 233.8 to el 338.0; these dikes were not included in plan A.

<u>c</u>. The closure dike across the existing channel at mile 235.0 was lowered from el 338 to 336. This would not be a construction sequence but an assumption that the dike would be constructed to that elevation initially.

Results

34. Results given in Plate 16 show that the channel in the crossing toward the left bank moved toward the completed portion of the longitudinal dike and the completed spur dikes near the right bank. The channel along the new alignment upstream of the island had not developed to project depth by the end of the test of this plan. A channel of adequate depth but of poor alignment and limited width extended from the end of the spur dike at mile 236.3 toward the upper end of the stone-fill revetment at mile 236.2. The channel between the island at mile 235.5 and the left bank increased in width. Results indicated a tendency for the lower end of the island to erode. Some scouring of the shoal along the ends of the spur dikes along the left bank (miles 234.1 to 233.8) occurred, but a channel of adequate width had not developed in this reach by the end of the test.

Plan C

Description

35. Plan C (Plate 17) was the same as the start of plan B (paragraph 30) except that the left side of the island at mile 235.0 was molded with the same material as that in the bed of the main channel to permit it to erode by the action of currents. The test of the plan was started with the bed molded to the conditions obtained in the base test with modification of the island mentioned above and the molding of the left bank between miles 233.8 and 232.7 in erodible material. Other features the same as plan B included the closure dike at mile 236.9, two closure dikes with navigation gaps at miles 235.7 and 235.0, and the revetment between miles 237.1 and 236.8 to el 347.

Results

36. Results of tests of this plan (Plate 18) were generally similar to the results of tests of plan B except that there was a greater tendency for the channel to meander in the crossing toward the left bank (miles 236.5 to 235.2). The channel in the crossing moved from the upper end of the stone-fill revetment at mile 236.2 to the head of the island at mile 235.7, eroding a portion of the island near the upper end. A sandbar developed along the stone-filled revetment at mile 235.7 and along the lower left side of the island at mile 235. The channel over the crossing toward the left bank (mile 236.2) had a poor alignment and was less than project width. As in plan B, the channel along the right bank approaching the navigation gap in the closure dike at mile 235.7 had shoaled to less than project depth.

Plan C-1

Description

37. Plan C-1 was the same as plan C except that the navigation gaps in the closure dikes at miles 235.7 and 235.0 were eliminated by

filling to the elevation (338) of the dikes, and the closure dike between the island and left bank at mile 236.9 was raised to el 343 and extended across the top of the island about 1700 ft (Plate 17).

Results

38. Results shown in Plate 19 indicate that a channel of adequate width and depth would develop in the crossing toward the left bank (miles 237 to 235). However, the alignment of this channel was affected by the closure dike along the left bank which caused the crossing to move upstream making a sharp turn toward the head of the stone-fill revetment at mile 236.2 where a deep scour hole developed. A sandbar developed along most of the revetment downstream of the scour hole. Because of its location and alignment, the channel over the crossing at mile 236.7 would tend to be unstable and affected by flow conditions. Downstream of the island and the proposed bridge, a narrow channel of adequate depth developed along the left bank with a shoal area between that channel and the channel to the right. The channel over the crossing from the left bank toward the right bank at 232.5 had moved to the left, forming a sharp angle with the alignment of the right bank.

Plan C-2

39. Plan C-2 was the same as plan C-1 except that the closure dike at mile 235.7 was raised from el 338 to 340 (Plate 17). The raising of the dike improved the channel along the stone-fill revetment, along the left bank downstream, and into the crossing toward the right bank at mile 232.5 (Plate 20). However, the crossing toward the stone-fill revetment at mile 236.5 had shoaled to less than project depth.

Plan C-3

40. Plan C-3 was the same as plan C-2 except for the installation of a 950-ft-long vane dike with crest at el 338 along the left side of the channel in the crossing at mile 236.5 (Plate 17). With the

vane dike, a channel of excellent alignment and minimum width of more than 700 ft developed over the crossing at mile 236.5. A good channel also developed along the stone-fill revetment downstream. In the reach below the proposed bridge location, a divided channel formed, reducing the width of the channel along the left bank at mile 234. Although adequate width and depth would be provided in the channel to the right, the alignment of that channel would not provide a satisfactory approach to the proposed bridge navigation span (Plate 21).

Plan C-4

41. Plan C-4 involved the construction of a spur dike along the right bank at mile 234.4 to el 339 with other conditions being the same as those obtained at the end of the test of plan C-3 (Plate 17). The dike was designed to improve the channel along the left bank below the proposed bridge. The dike caused erosion of the upper end of the center bar at mile 234.3 and provided a better approach channel to the bridge navigation span. In the upper reach at mile 236, a sandbar formed along the right side of the channel that could affect navigation if the sandbar continued to develop.

Plan C-5

42. Conditions for plan C-5 were the same as those obtained at the end of the test of plan C-4 except that a spur dike with top el 338 was added along the right bank at mile 234 (Plate 17). The dike included in this plan produced an increase in the erosion of the head and right side of the sandbar along the left bank and improved the alignment of the channel downstream of the bridge. The sandbar at mile 236.0 encroached on the channel over the crossing such that it could possibly create some future maintenance problems.

Plan C-6

Description

43. The conditions for the start of the test of plan C-6 were the same as those obtained at the end of the test of plan C-5 except for the installation of a spur dike with top el 341 along the right bank at mile 236.2. The end of the dike was located to maintain a clear channel width of 1200 ft. In addition to the test with the typical hydrograph, this plan was also tested with a low hydrograph (discharges of the typical hydrograph reduced 50 percent) and with the fast-rising flood hydrograph shown in Plate 6.

Results

44. Results of the test with the typical hydrograph (Plate 22) indicate that the sandbar which had encroached on the channel over the crossing at mile 236 would be eliminated, and an adequate channel of good alignment would be developed through the reach. There was little change in the channel downstream of the proposed bridge location.

45. Results shown in Plate 23 indicate that a reduction in discharge of 50 percent would have little effect on channel development in the reach under study. The fast-rising flood hydrograph produced some reduction in the depths along the channel, but the effects were not sufficient to adversely affect the navigable channel (Plate 24). Generally, depths were increased in some areas and decreased in others.

46. As in the tests with the channel diverted toward the left bank over the crossing at mile 236, a sandbar tended to form along the left bank downstream of the lower approach to the proposed bridge navigation span. By the end of the test of plan C-6, the sandbar along the bank extended from about mile 234.2 to about mile 233.5, eliminating or reducing the tendency for erosion of the left bank in that reach. However, there would be a tendency for the left bank to erode downstream of the sandbar and for the crossing at mile 232.5 to move toward the left with deposition occurring along the right side. Some erosion of the left bank would tend to improve the alignment of the channel over the crossing and eliminate the sharp angle approaching the right bank.

PART IV: DISCUSSION AND SUMMARY OF RESULTS AND INDICATIONS

Model Results

47. When results of movable-bed model studies are analyzed, the limitations of the models in reproducing accurately all of the factors affecting developments within the reach of river under study must be considered. Generally, some adjustments in the scale relations and operating procedures will be required until the model demonstrates the ability to reproduce with reasonable accuracy the general configurations and trends indicated by prototype surveys. In spite of the adjustment and verification of the model used in this investigation, certain limitations have to be considered in the evaluation and interpretation of model results. The banks of the river channel in most places were fixed in the model, and it was not possible to accurately reproduce the action of bank caving. Also, the reach was complicated by many islands, sandbars, and divided channels, with and without vegetation. Information on the erodibility of these islands and sandbars was not available and, if available, could not have been reproduced in the model with any degree of accuracy. Also, the model did not reproduce the movement of material in suspension and its effect upon channel development.

48. In spite of the limitations mentioned, the adjustment and verification of the model was sufficient to indicate the trends that can be expected under the conditions imposed for each plan or modification tested and the relative effectiveness of such plan.

Summary of Results and Conclusions

49. The channel through the reach under study, particularly between miles 237 and 234, would tend to be unstable under conditions existing at the time of the 1973 survey. Developments in the reach would be affected by flow conditions and flow that is diverted through side channels.

50. With most of the flow through the channel along the right bank, currents would tend to directly impinge against the left bank between miles 234.2 and 233.5, which could cause progressive erosion and caving of the bank unless the bank is protected.

51. A satisfactory channel through the reach and in the approaches to the navigation span along the left bank of the proposed bridge can be developed by diverting flow toward the left bank at about mile 236.8. Development of this channel would require closure structures in the channel along the right bank downstream of the crossing.

52. A satisfactory channel in the crossing toward the left bank at mile 236 could be developed with either plan A-4 or plan C-6, but plan C-6 would require less construction.

53. Development of a channel toward the left bank upstream of the proposed highway bridge should not be adversely affected by unusually long low-water periods. With flood flows there would be a tendency for some reduction in depths because of the dispersion of flow over the closure dikes and overbank areas. The effects of these flows would depend on their magnitude and duration.

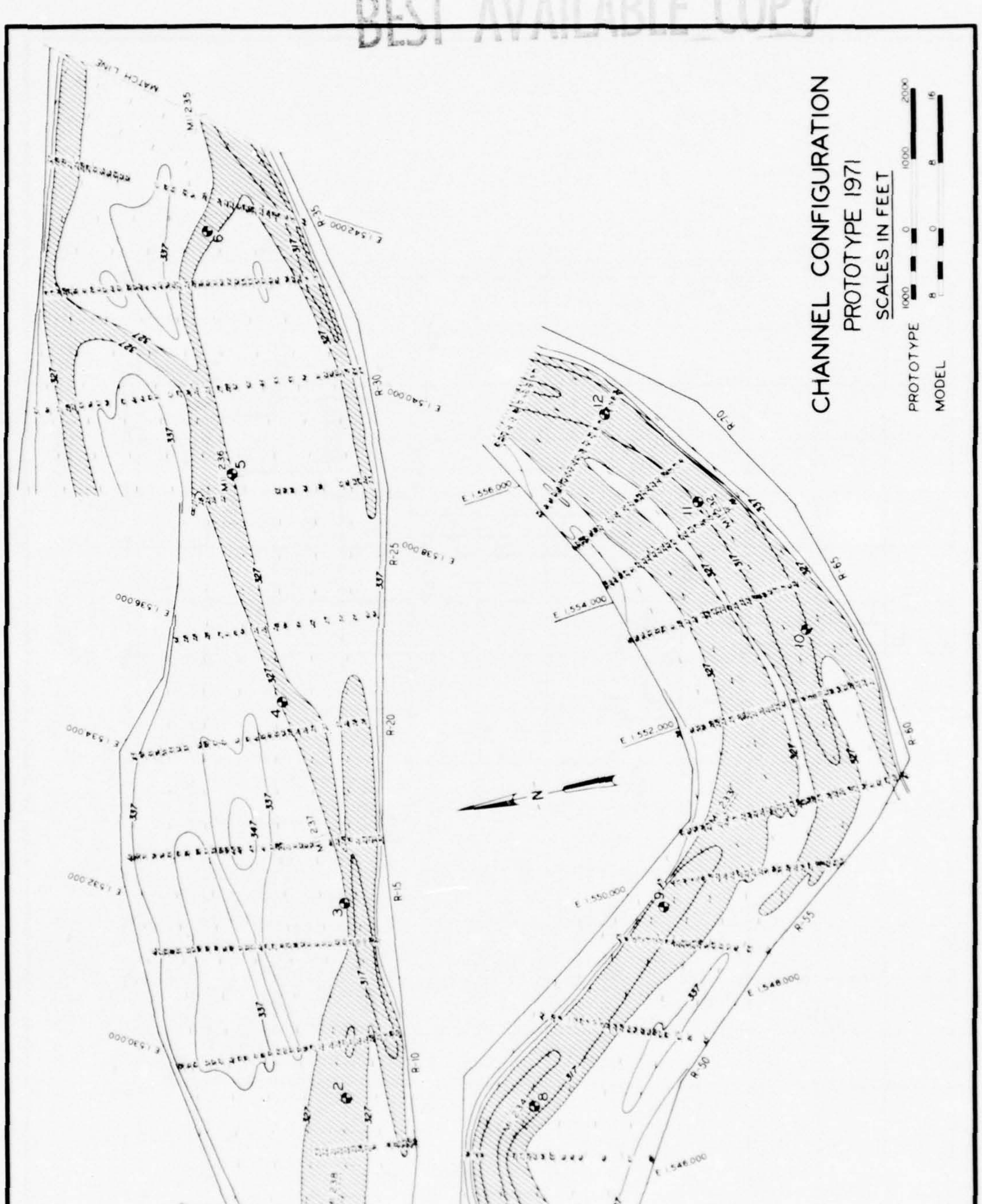
54. The provision of navigation gaps in the closure dikes at miles 235.7 and 235.2 would tend to reduce velocities upstream, cause shoaling in the upper approaches to the gaps, and cause scouring downstream of the gaps.

55. With flow diverted toward the left bank upstream of the proposed bridge, a sandbar would tend to form along the left bank at about mile 234 and the channel would tend to form toward the right near the center of the bend after passing the navigation span of the proposed bridge. This development would tend to reduce the tendency for erosion and caving of the left bank between miles 234.2 and 233.5 and increase the attack on the left bank farther downstream.

56. Permitting a portion of the left bank below mile 233.5 to erode would tend to improve the alignment of the channel in the crossing toward the right bank downstream.

57. The tendency for the channel to move away from the left bank just below the proposed bridge and the development of the sandbar

along the bank downstream would tend to affect the alignment of the channel in the lower approach to the navigation span of the proposed bridge. Structures would be required to prevent the channel from moving too far to the right, particularly during the higher flows.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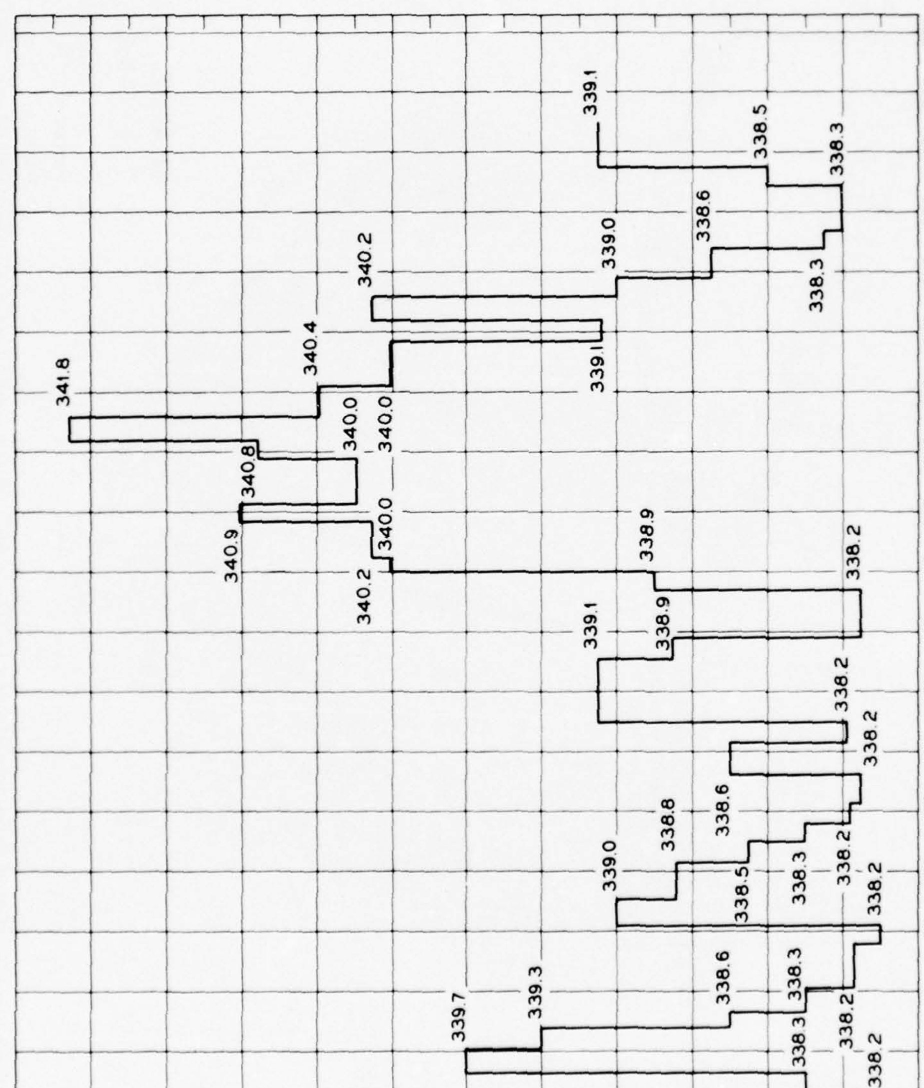
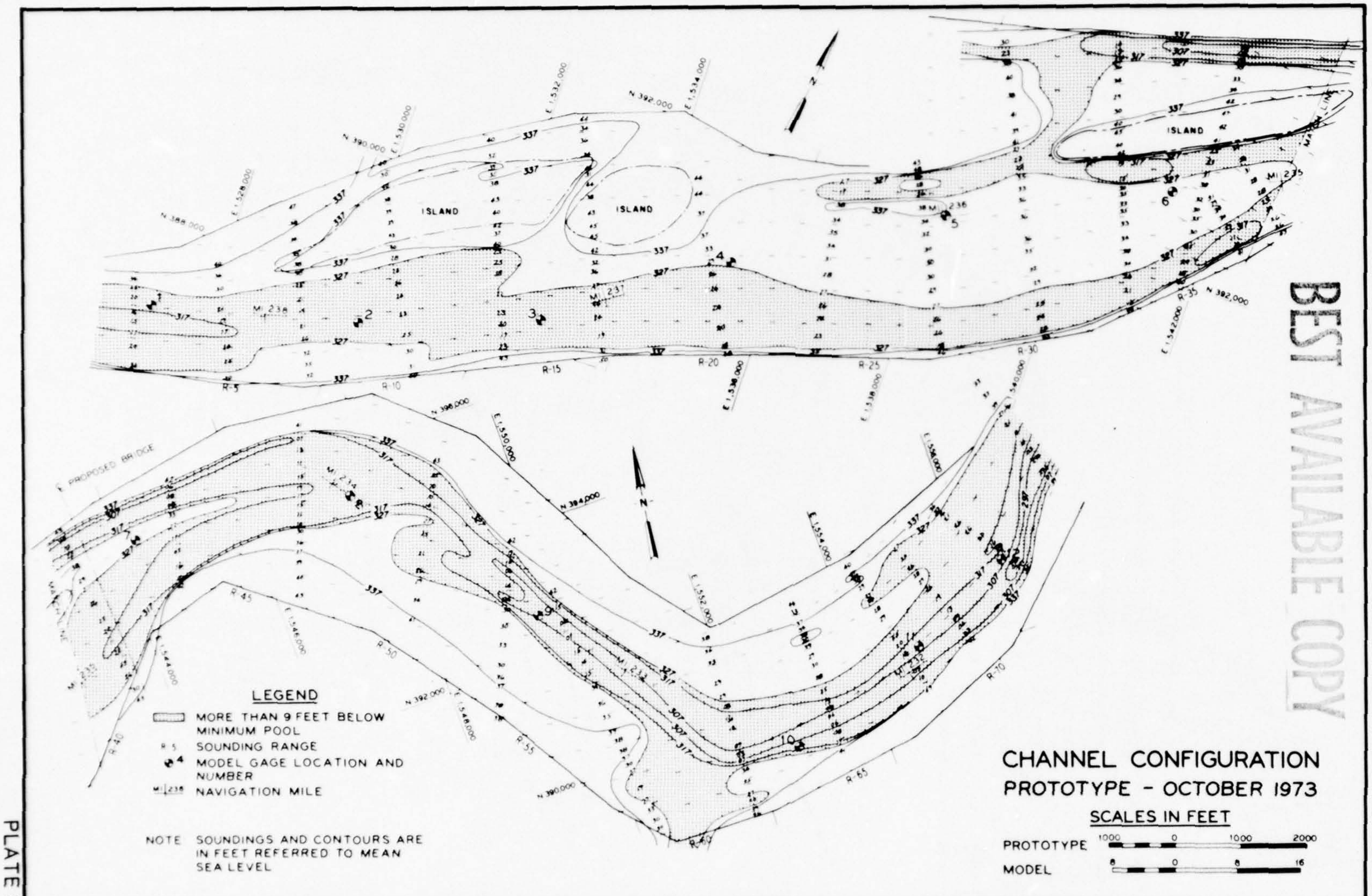
PROTOTYPE 1971
SCALES IN FEET
PROTOTYPE
MODEL
MATCH LINE
N



VERIFICATION HYDROGRAPH

PLATE 2



CHANNEL CONFIGURATION
PROTOTYPE - OCTOBER 1973

SCALES IN FEET

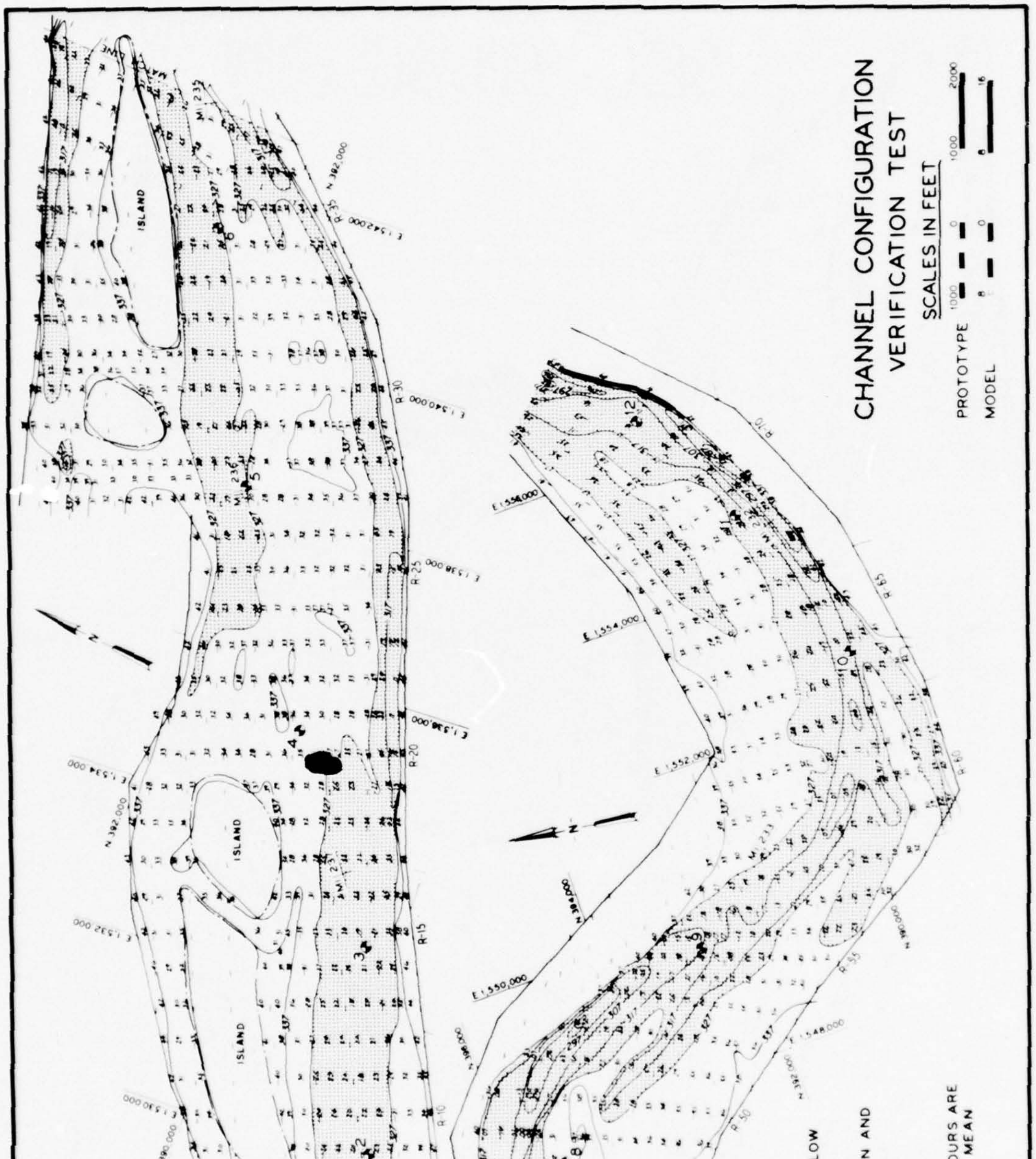
PROTOTYPE 1000 0 1000 2000

MODEL 8 0 8 16

LEGEND

- MORE THAN 9 FEET BELOW MINIMUM POOL
- R-5 SOUNDING RANGE
- 4 MODEL GAGE LOCATION AND NUMBER
- MI 238 NAVIGATION MILE

NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL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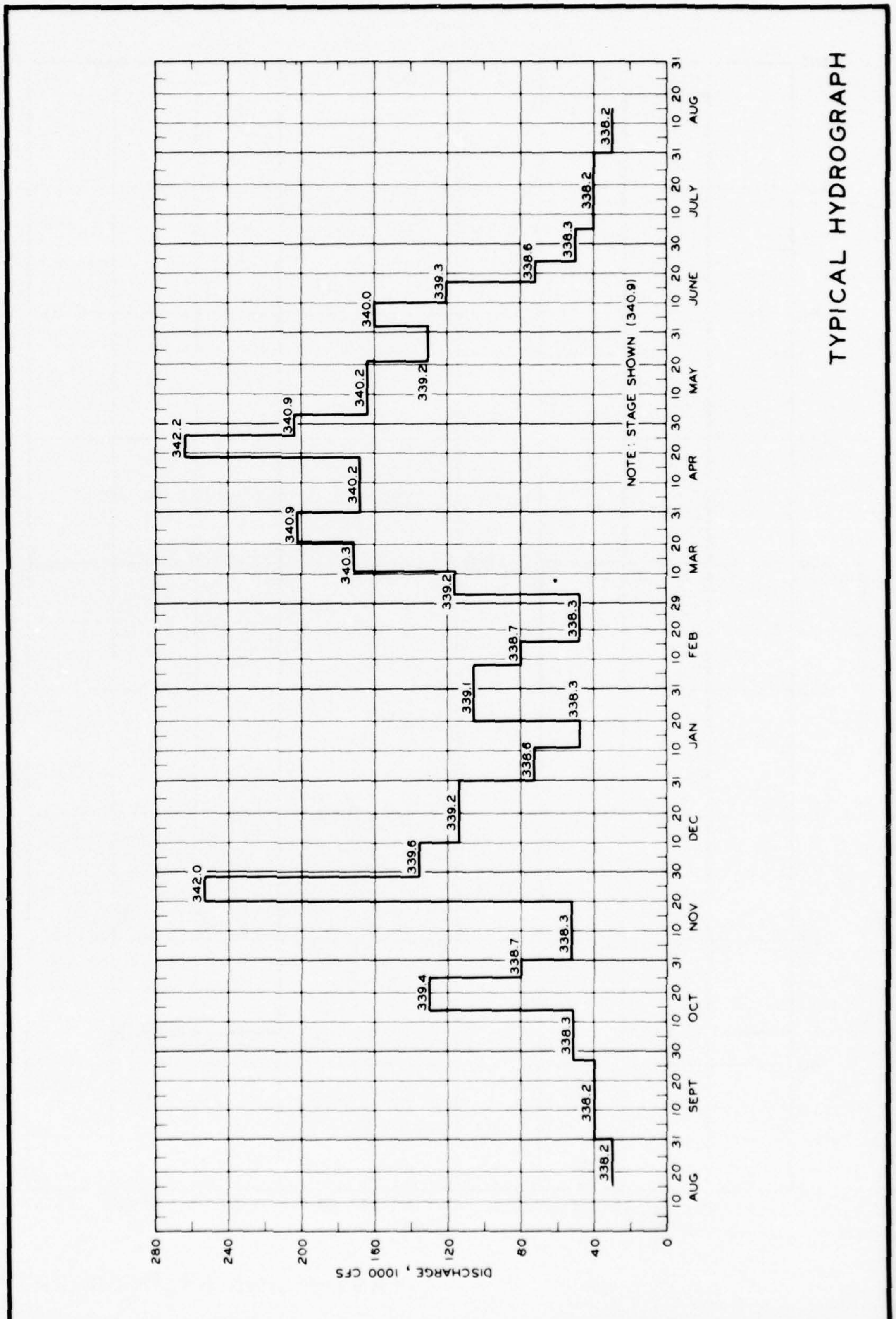
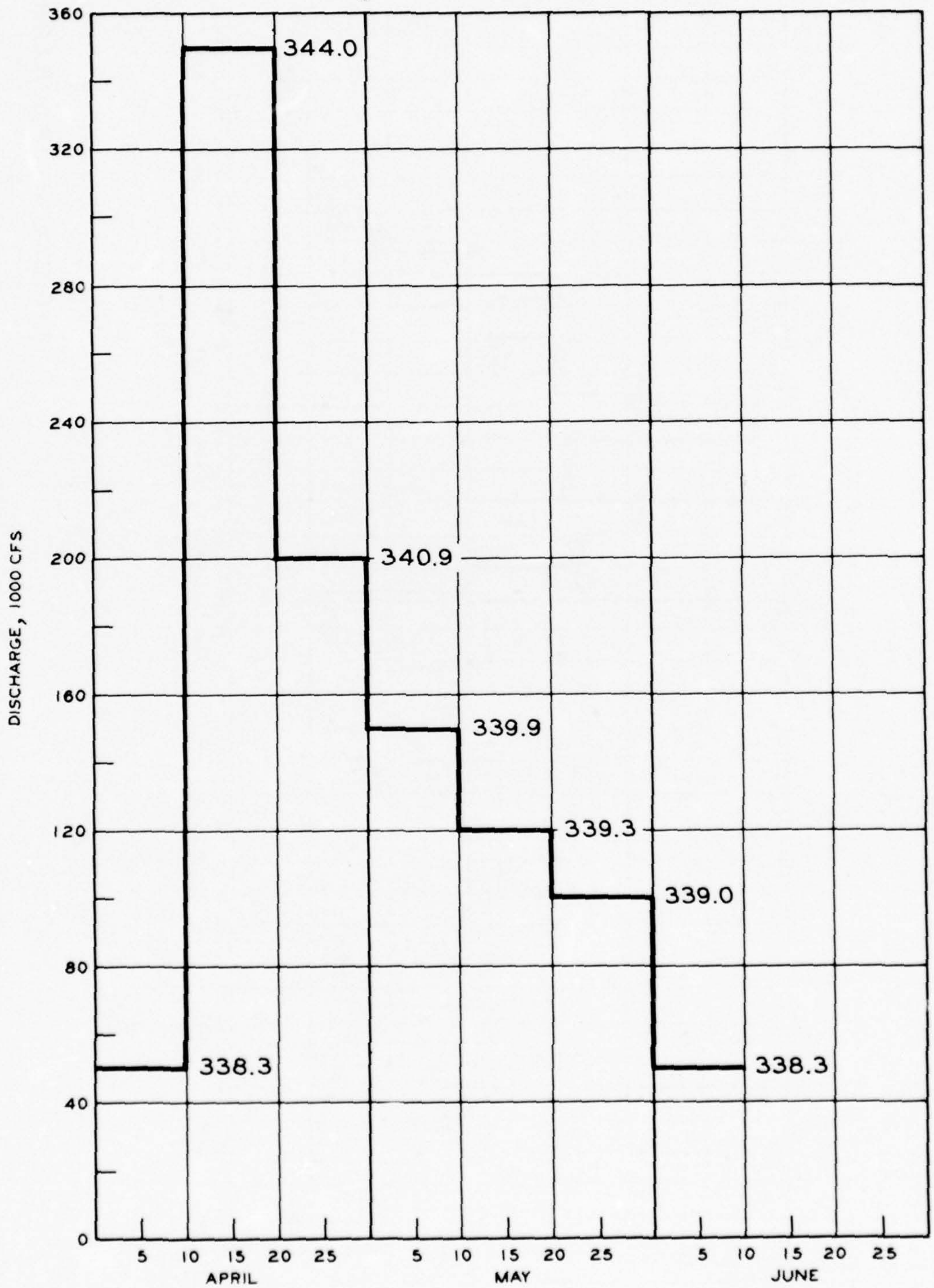
VERIFICATION TEST
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
ISLAND
ISLAND
ISLAND
PROPOSED BRIDGE

PLATE 4

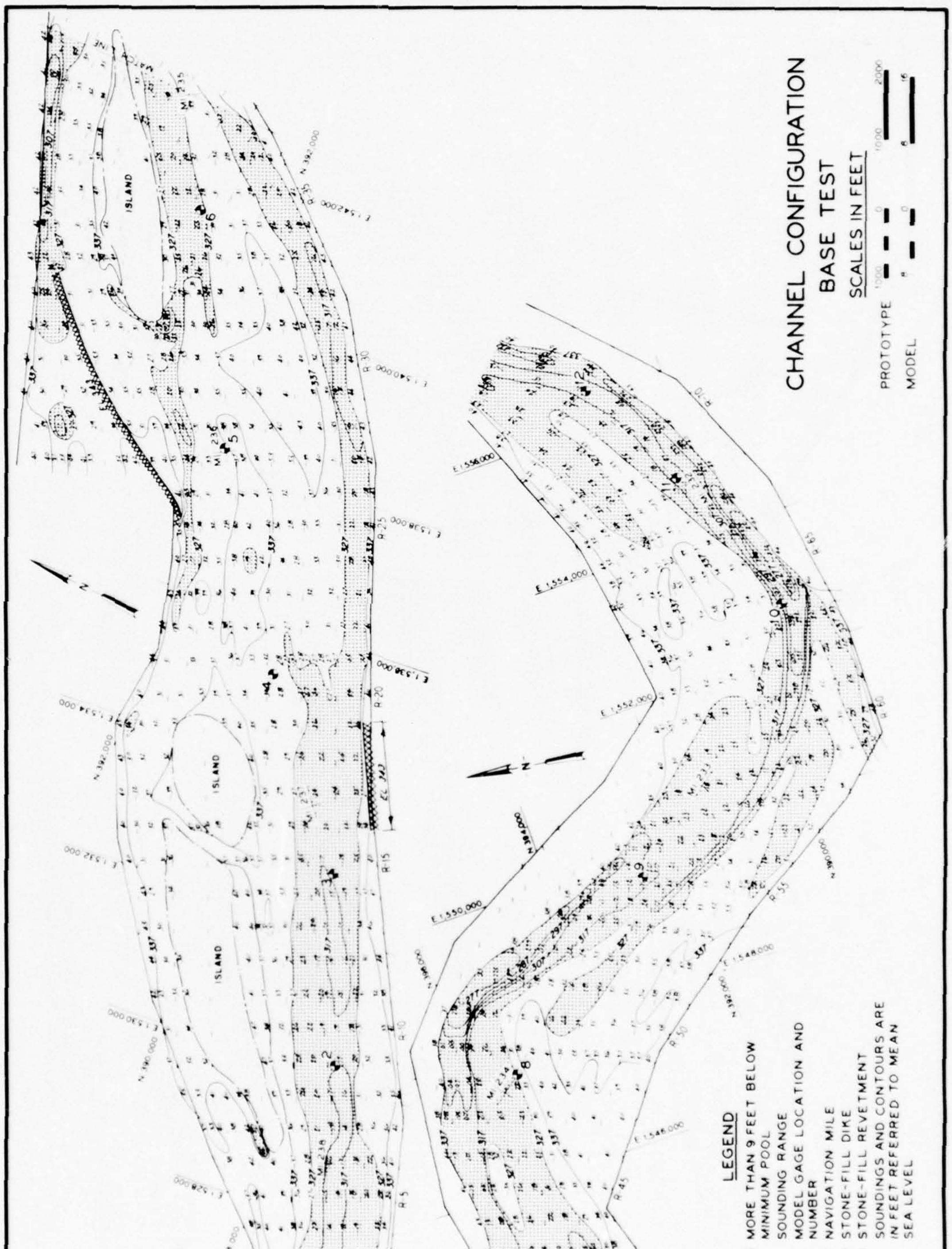


TYPICAL HYDROGRAPH



FAST-RISING HYDROGRAPH

PLATE 6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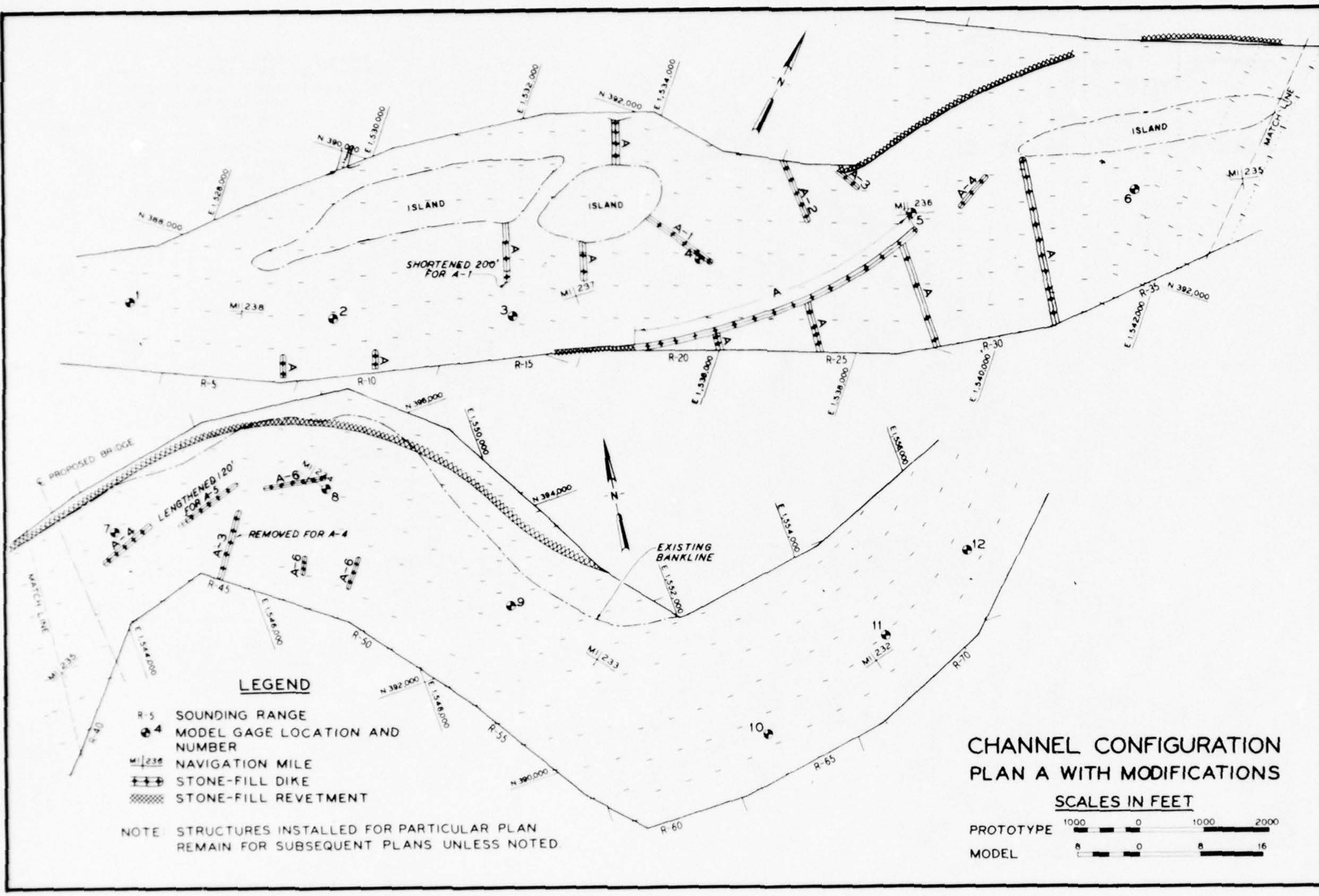
BASE TEST
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
ISLAND
ISLAND
ISLAND
MATCH LINE
PROPOSED BRIDGE

PLATE 7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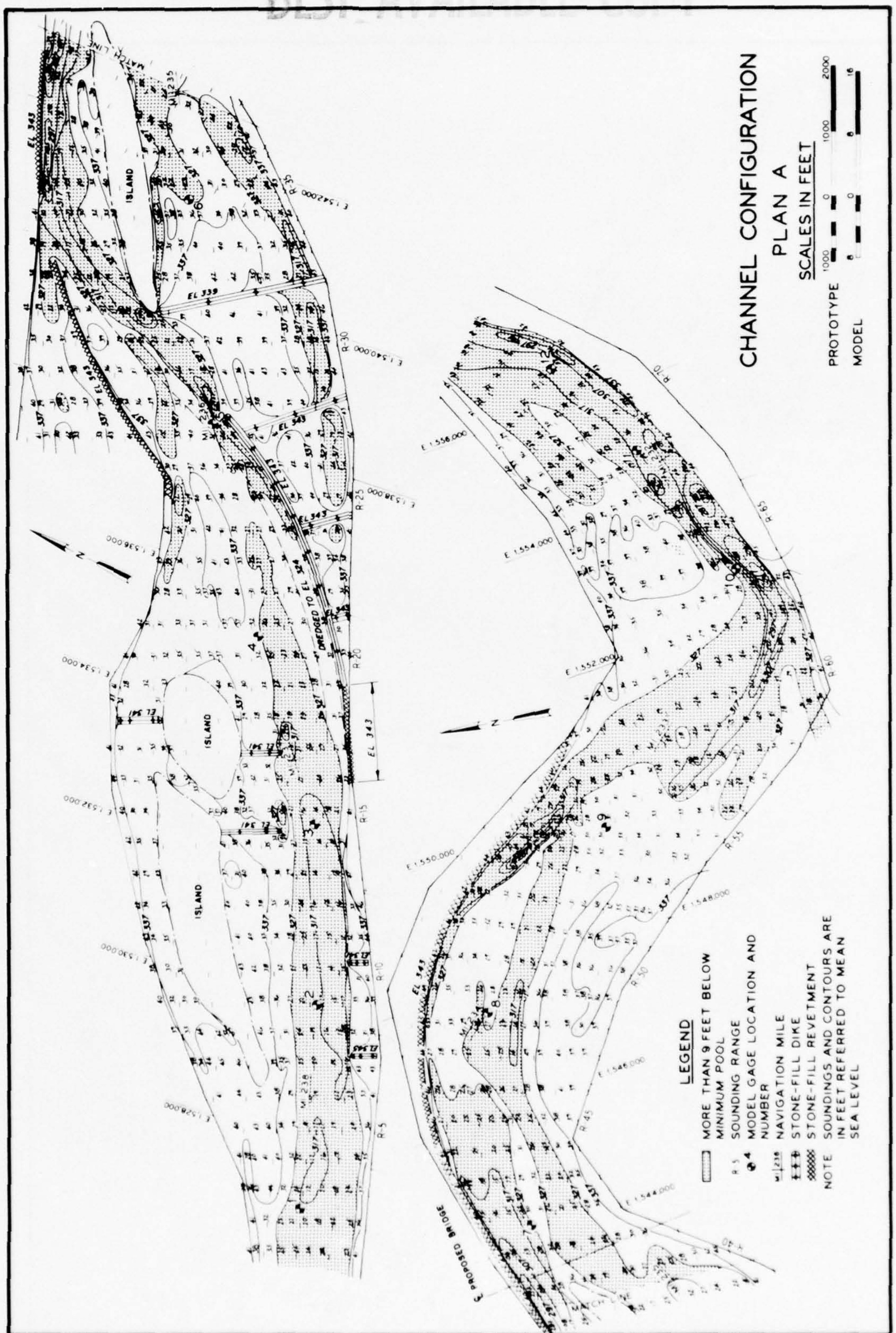
PLAN A WITH MODIFICATIONS
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 8 0 8 16
LEGEND
R-5 SOUNDING RANGE
4 MODEL GAGE LOCATION AND NUMBER
MI 236 NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE: STRUCTURES INSTALLED FOR PARTICULAR PLAN REMAIN FOR SUBSEQUENT PLANS UNLESS NOTED
ISLAND
ISLAND
ISLAND
SHORTENED 200' FOR A-1
LENGTHENED 120' FOR A-5
REMOVED FOR A-4
EXISTING BANKLINE
PROPOSED BRIDGE
MATCH LINE
MATCH LINE
N
N

PLATE 8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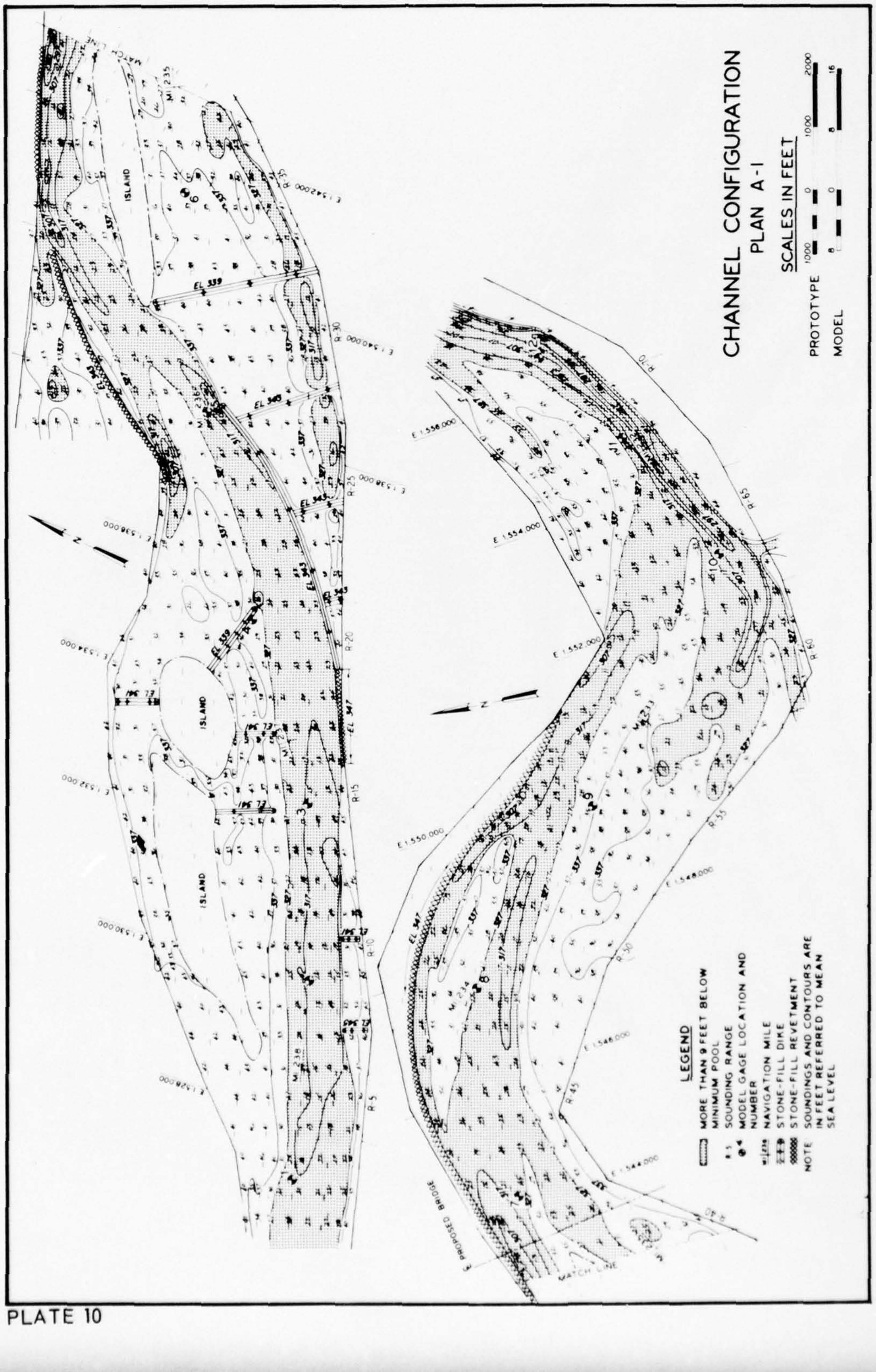
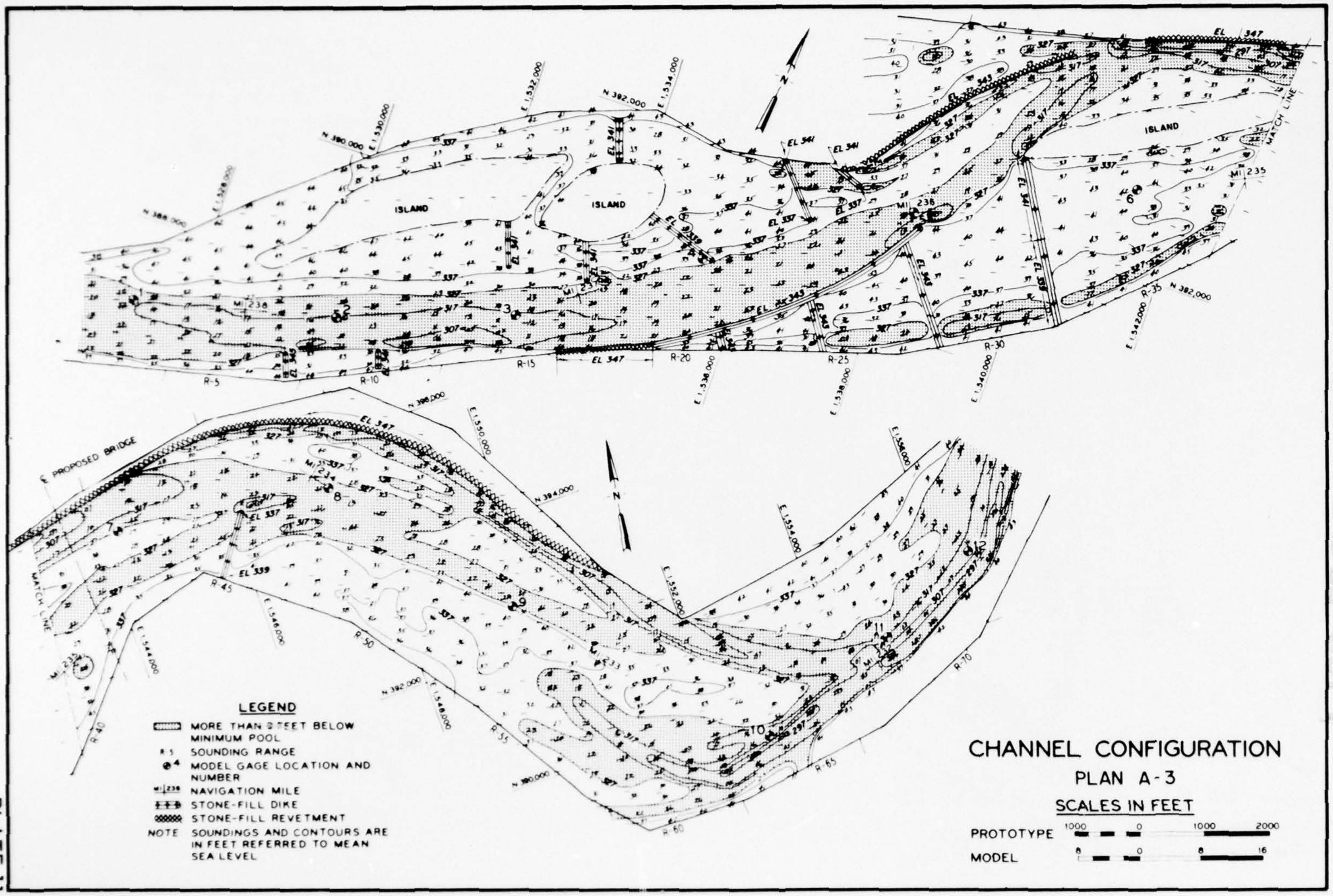
PLAN A
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 8 0 8 16
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
ISLAND
ISLAND
ISLAND
DREDGED TO EL 324
EL 343
MATCH LINE
MATCH LINE
PROPOSED BRIDGE

PLATE 9


CHANNEL CONFIGURATION
PLAN A-1
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 8 0 8 16
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
ISLAND
MATCH LINE
PROPOSED BRIDGE


LEGEND
MORE THAN 2 FEET BELOW MINIMUM POOL
SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PLAN A-3
SCALES IN FEET
PROTOTYPE
MODEL
ISLAND
MATCH LINE
PROPOSED BRIDGE

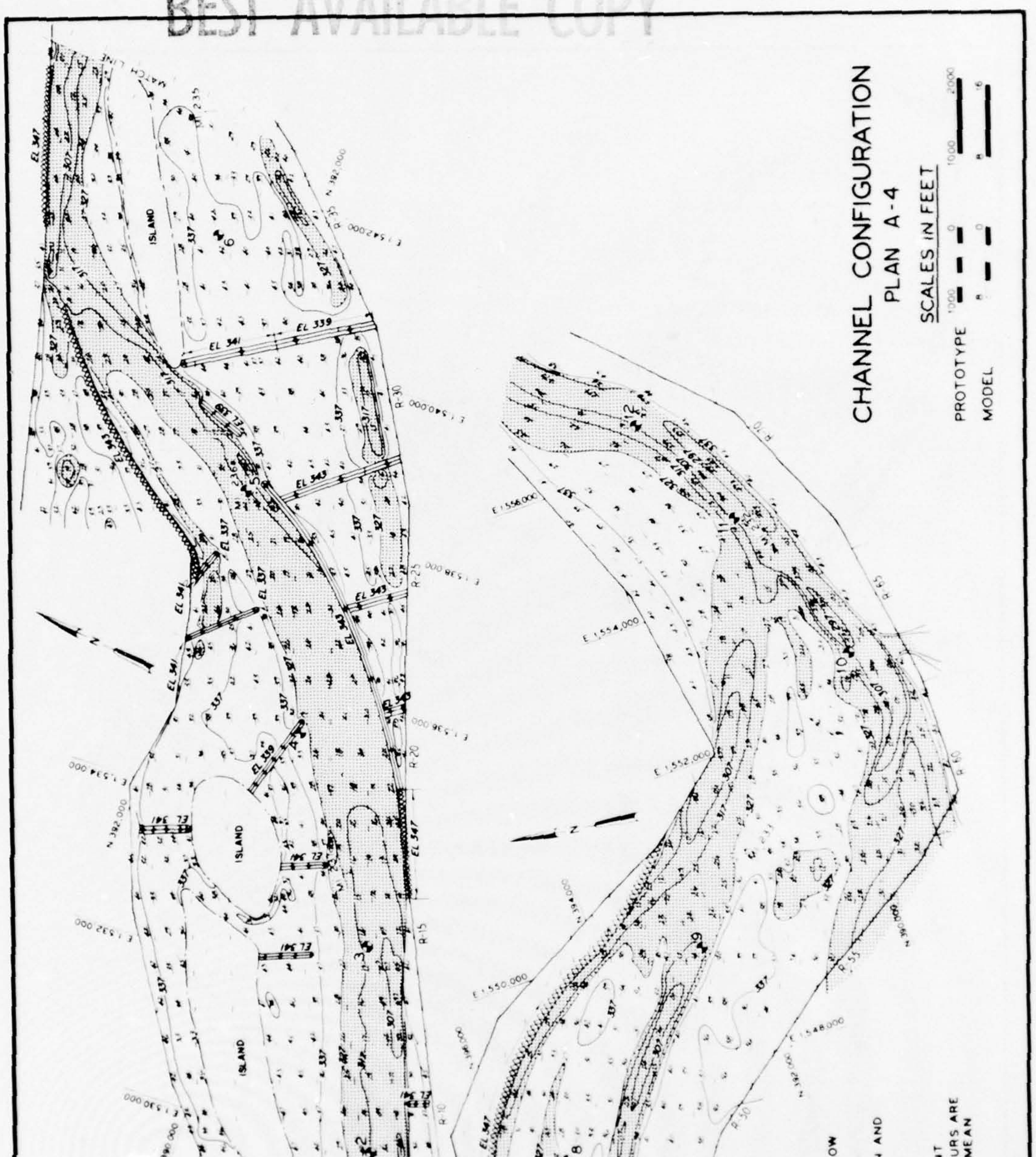
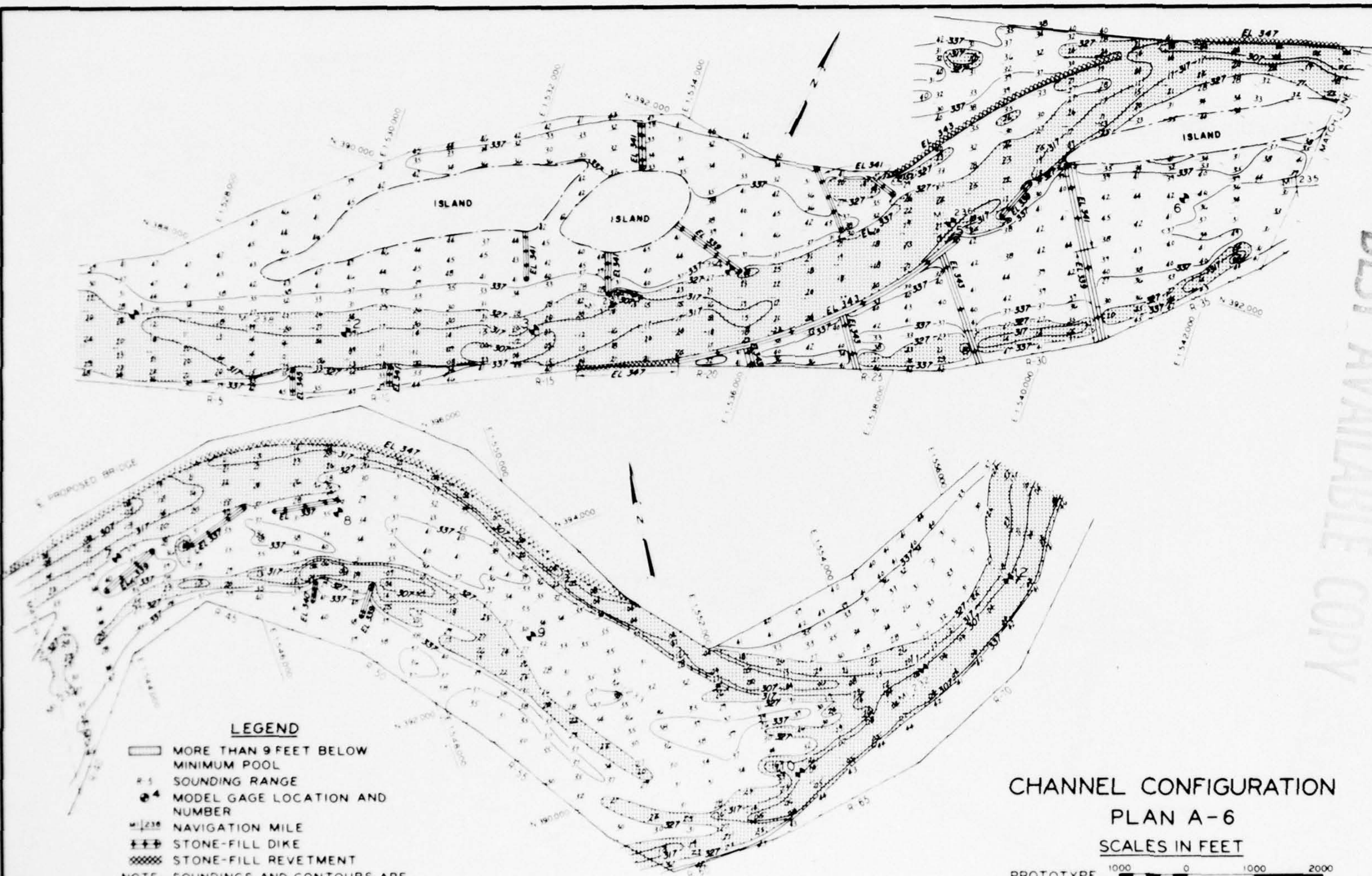

CHANNEL CONFIGURATION
PLAN A-4
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
ISLAND
MATCH LINE

PLATE 12



LEGEND

- MORE THAN 9 FEET BELOW MINIMUM POOL
- R-5 SOUNDING RANGE
- MODEL GAGE LOCATION AND NUMBER
- NAVIGATION MILE
- STONE-FILL DIKE
- STONE-FILL REVETMENT

NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL

CHANNEL CONFIGURATION
PLAN A-6

SCALES IN FEET

PROTOTYPE 1000 0 1000 2000

MODEL 8 0 8 16

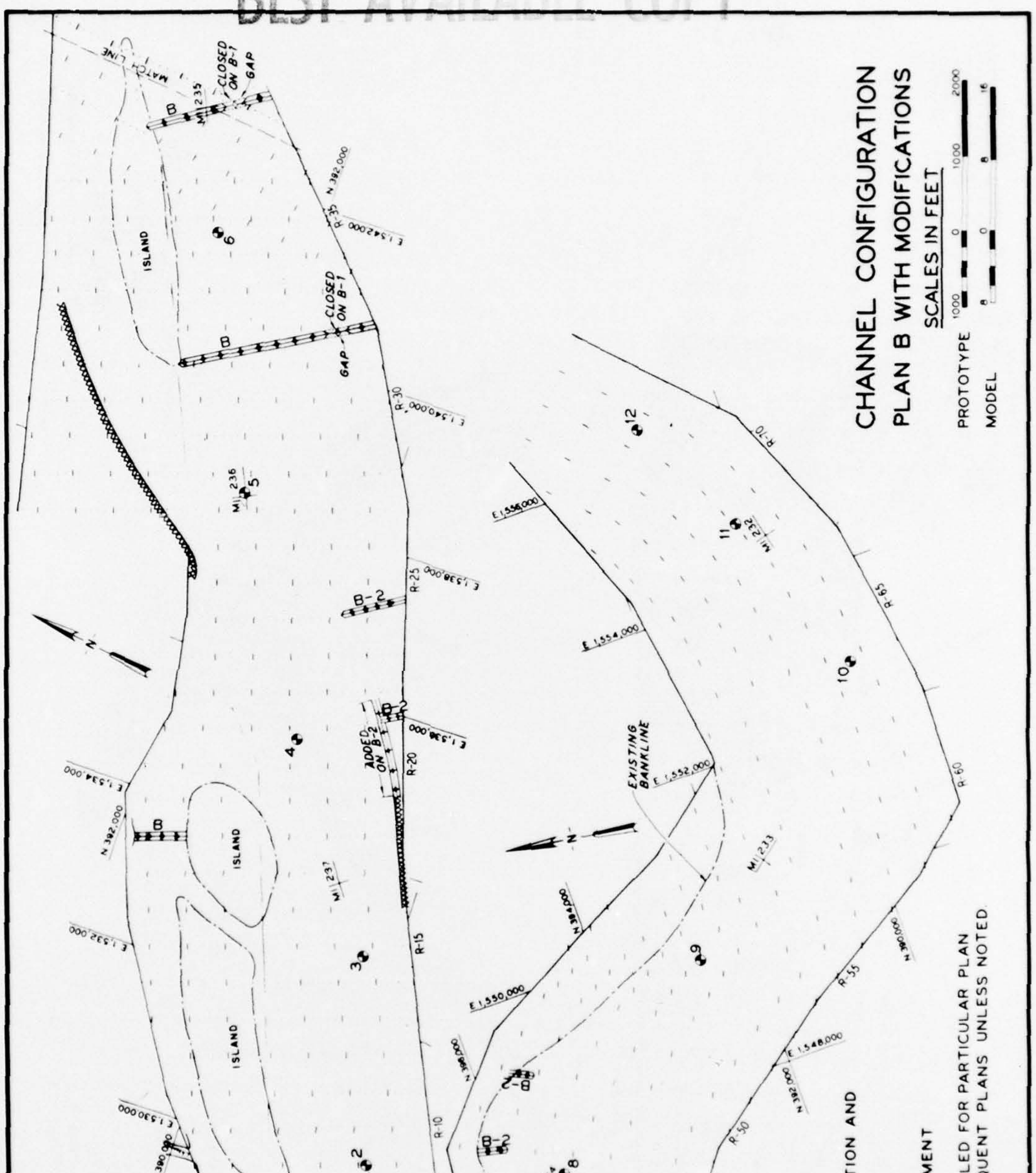
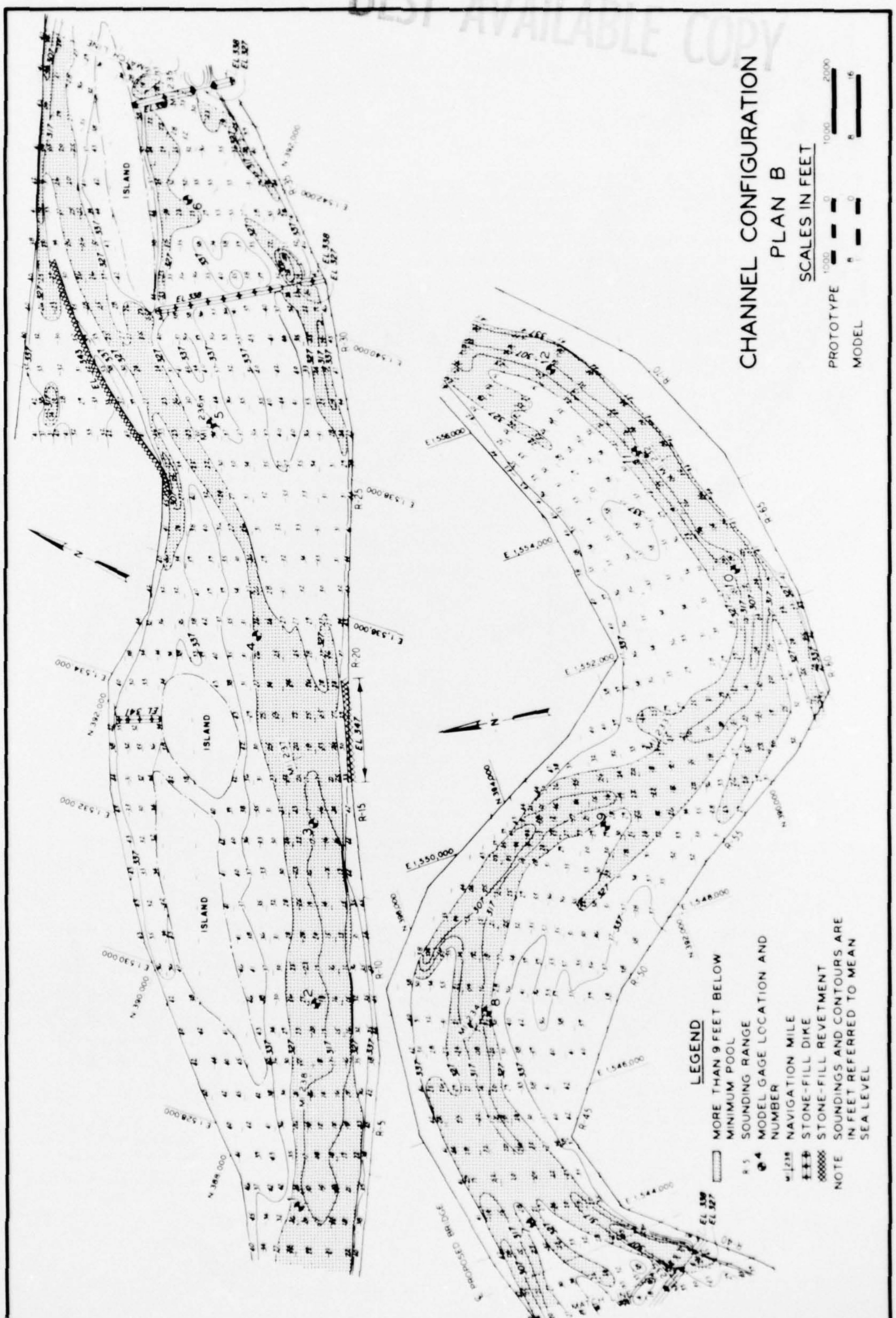
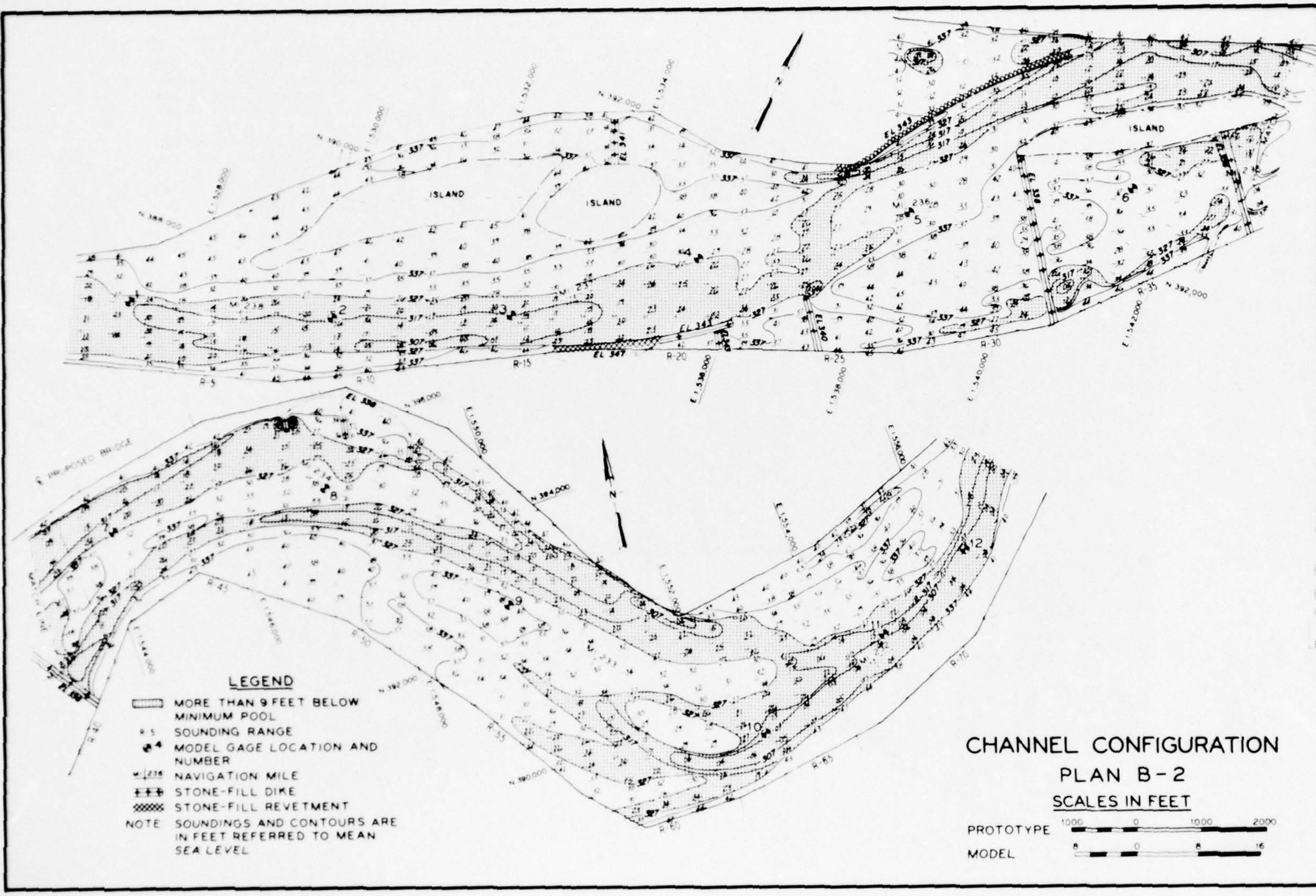

CHANNEL CONFIGURATION
PLAN B WITH MODIFICATIONS
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 8 0 8 16
LEGEND
R-5 SOUNDING RANGE
4 MODEL GAGE LOCATION AND NUMBER
MI 238 NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE STRUCTURES INSTALLED FOR PARTICULAR PLAN REMAIN FOR SUBSEQUENT PLANS UNLESS NOTED
ISLAND
ISLAND
ISLAND
EXISTING BANKLINE
ADDED ON B-2
CLOSED ON B-1
GAP
MATCH LINE
PROPOSED BRIDGE
N

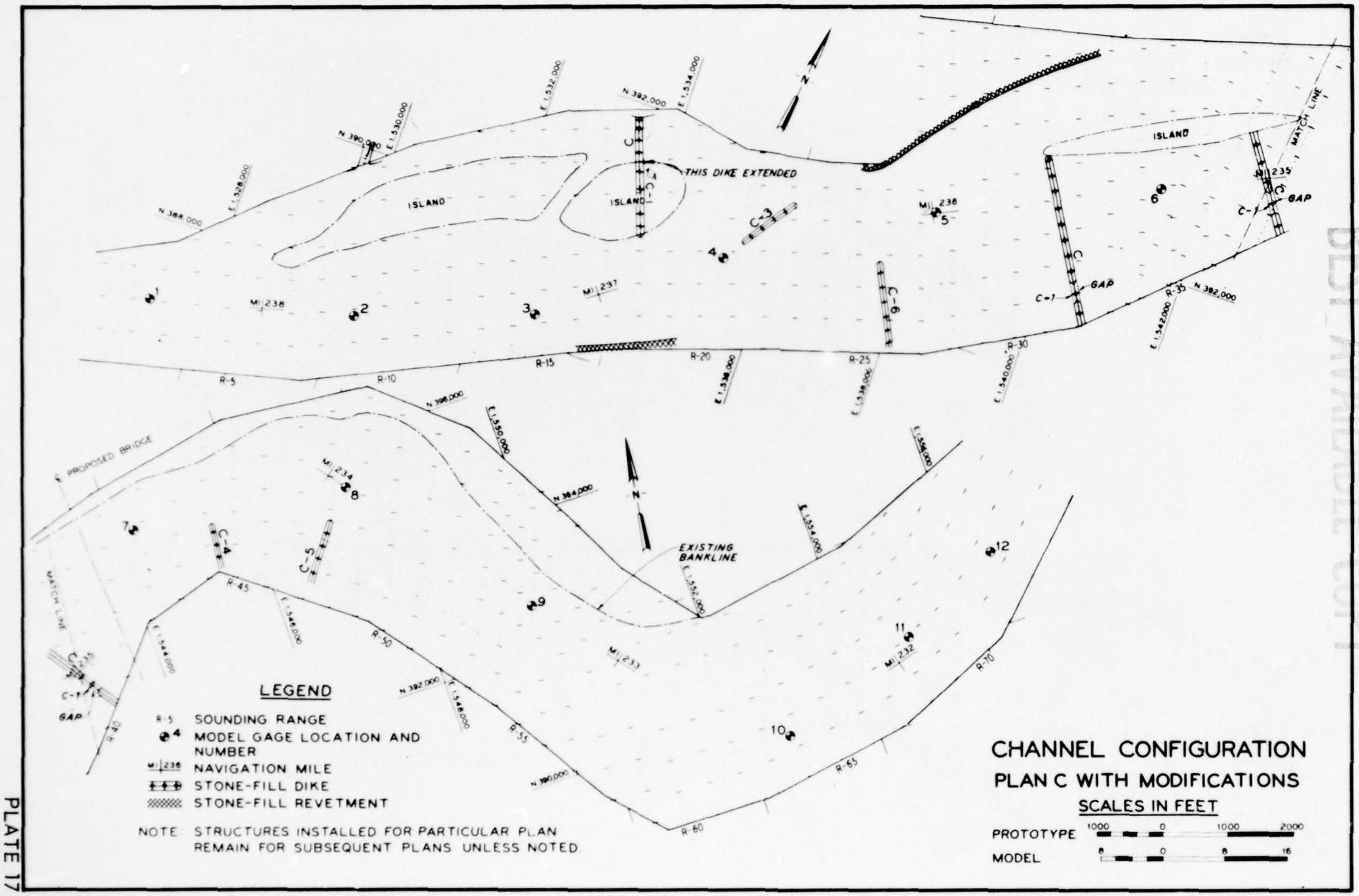
PLATE 14



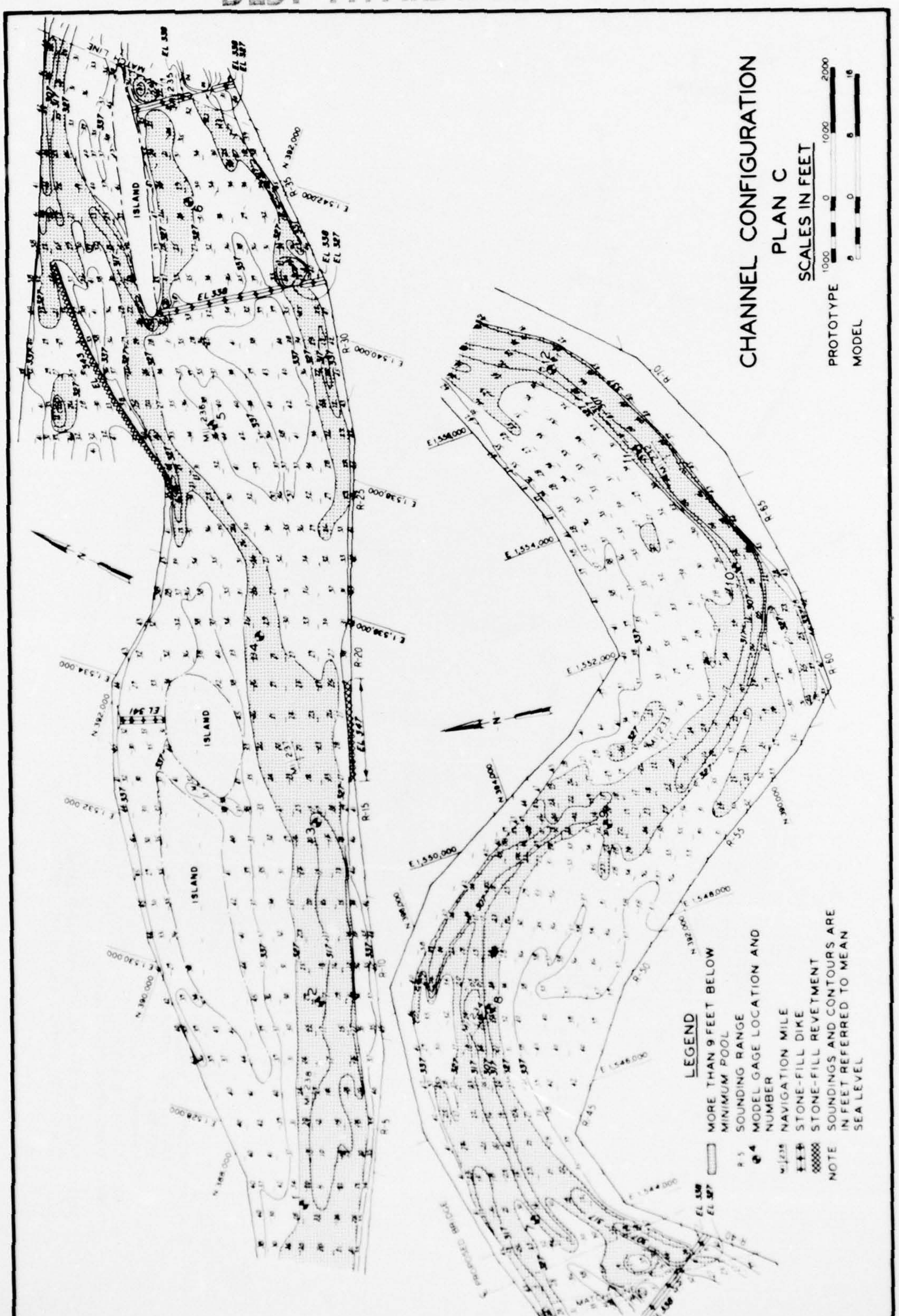
CHANNEL CONFIGURATION
PLAN B

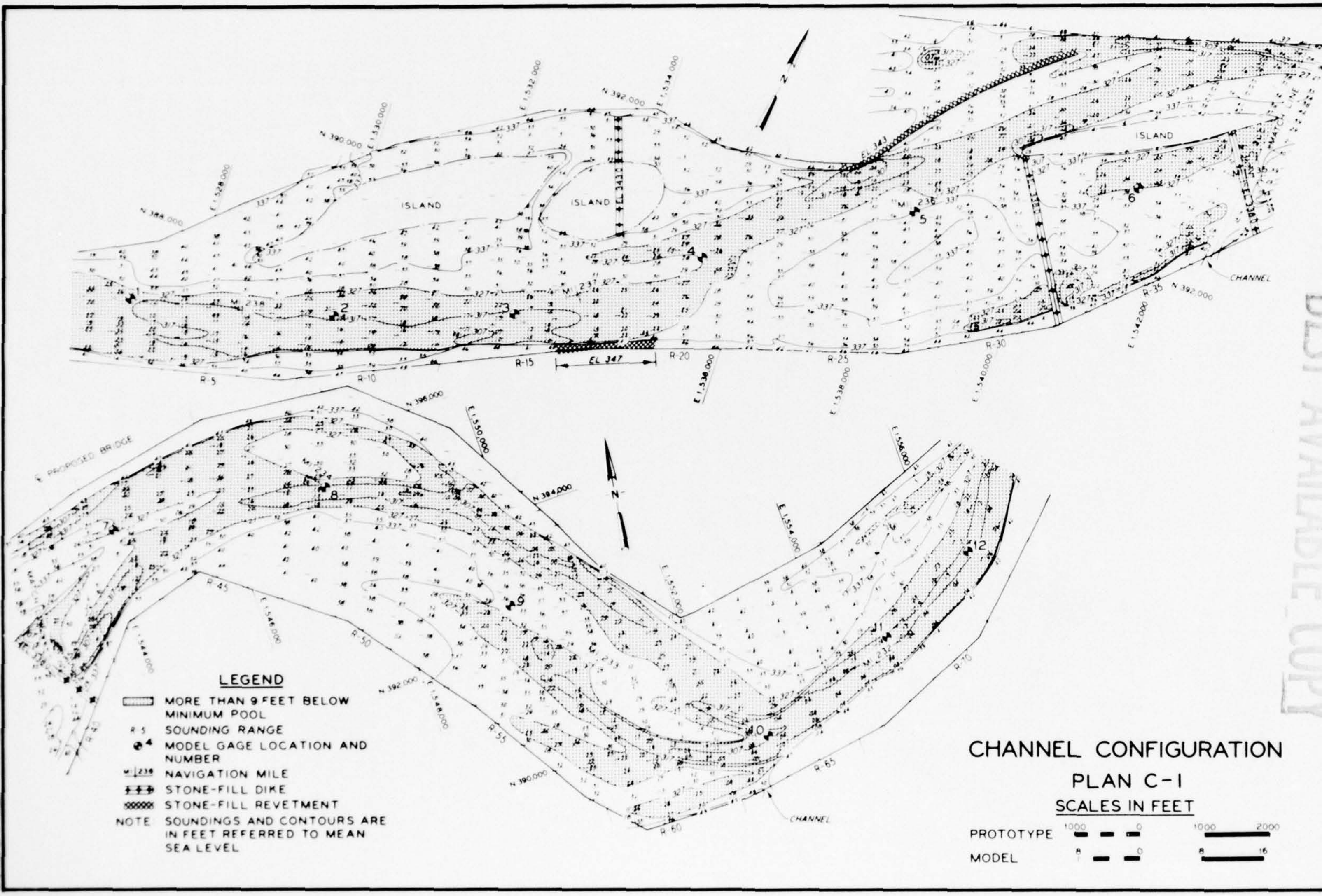


CHANNEL CONFIGURATION
PLAN B-2



THIS DIKE EXTENDED
ISLAND
EXISTING BANKLINE
PROPOSED BRIDGE
MATCH LINE
GAP
LEGEND
R-5 SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
MI 238 NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE: STRUCTURES INSTALLED FOR PARTICULAR PLAN REMAIN FOR SUBSEQUENT PLANS UNLESS NOTED.
CHANNEL CONFIGURATION
PLAN C WITH MODIFICATIONS
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 8 0 8 16

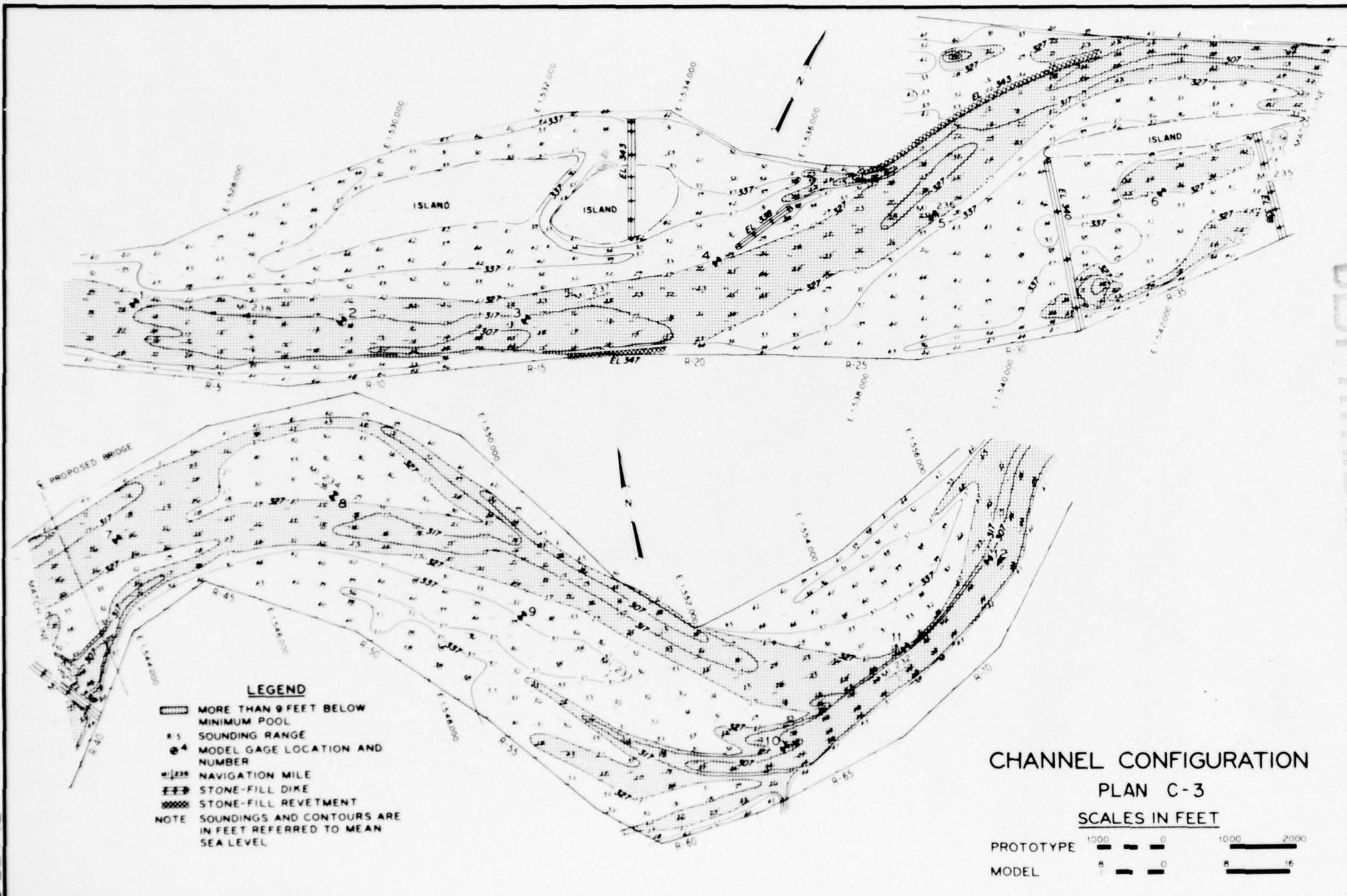

CHANNEL CONFIGURATION
PLAN C
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
ISLAND
MATCH LINE



CHANNEL CONFIGURATION
PLAN C-1


CHANNEL CONFIGURATION
PLAN C-2
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
ISLAND
ISLAND
ISLAND
CHANNEL
CHANNEL
EL 347

PLATE 20



CHANNEL CONFIGURATION
PLAN C-3

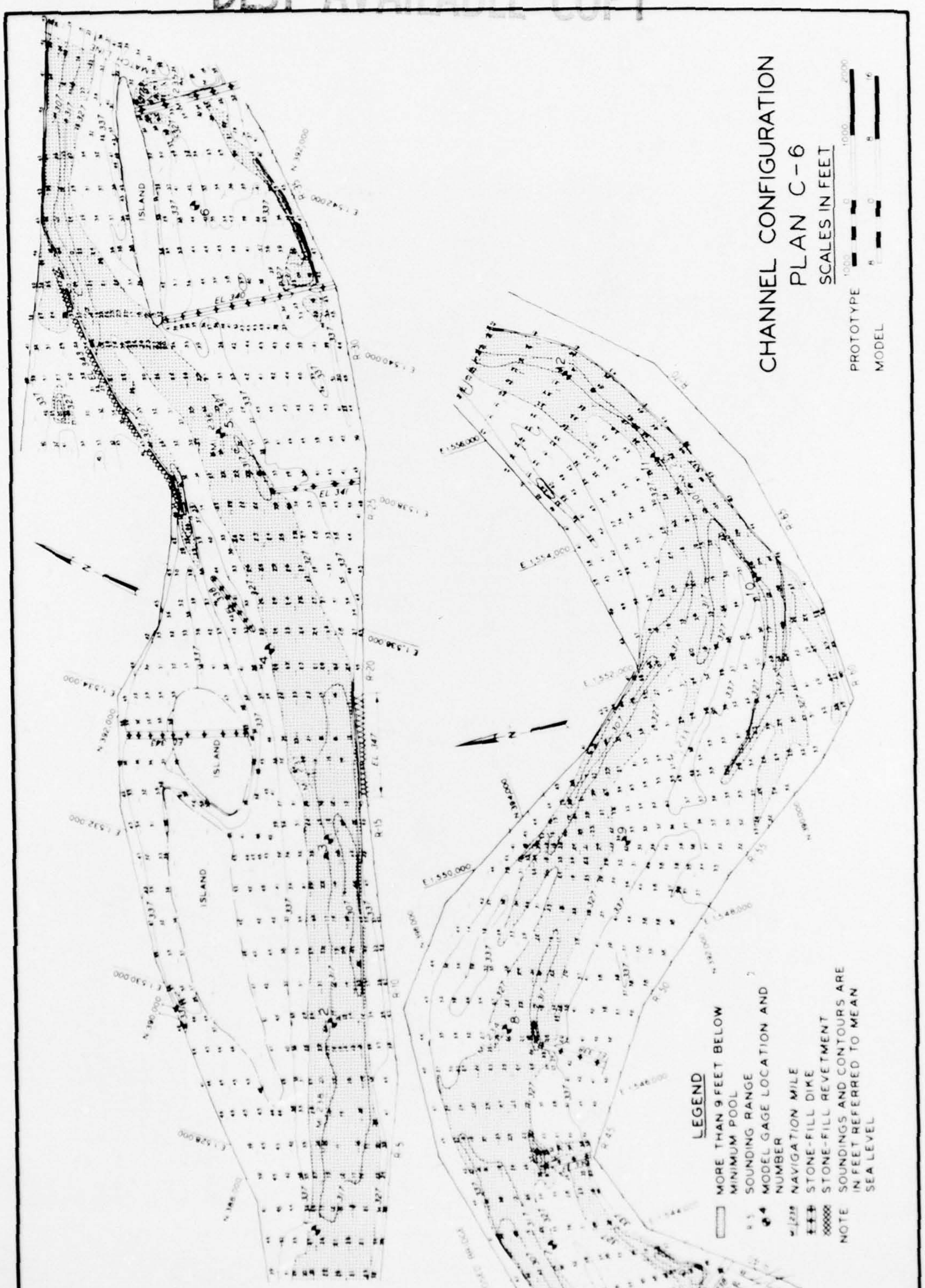
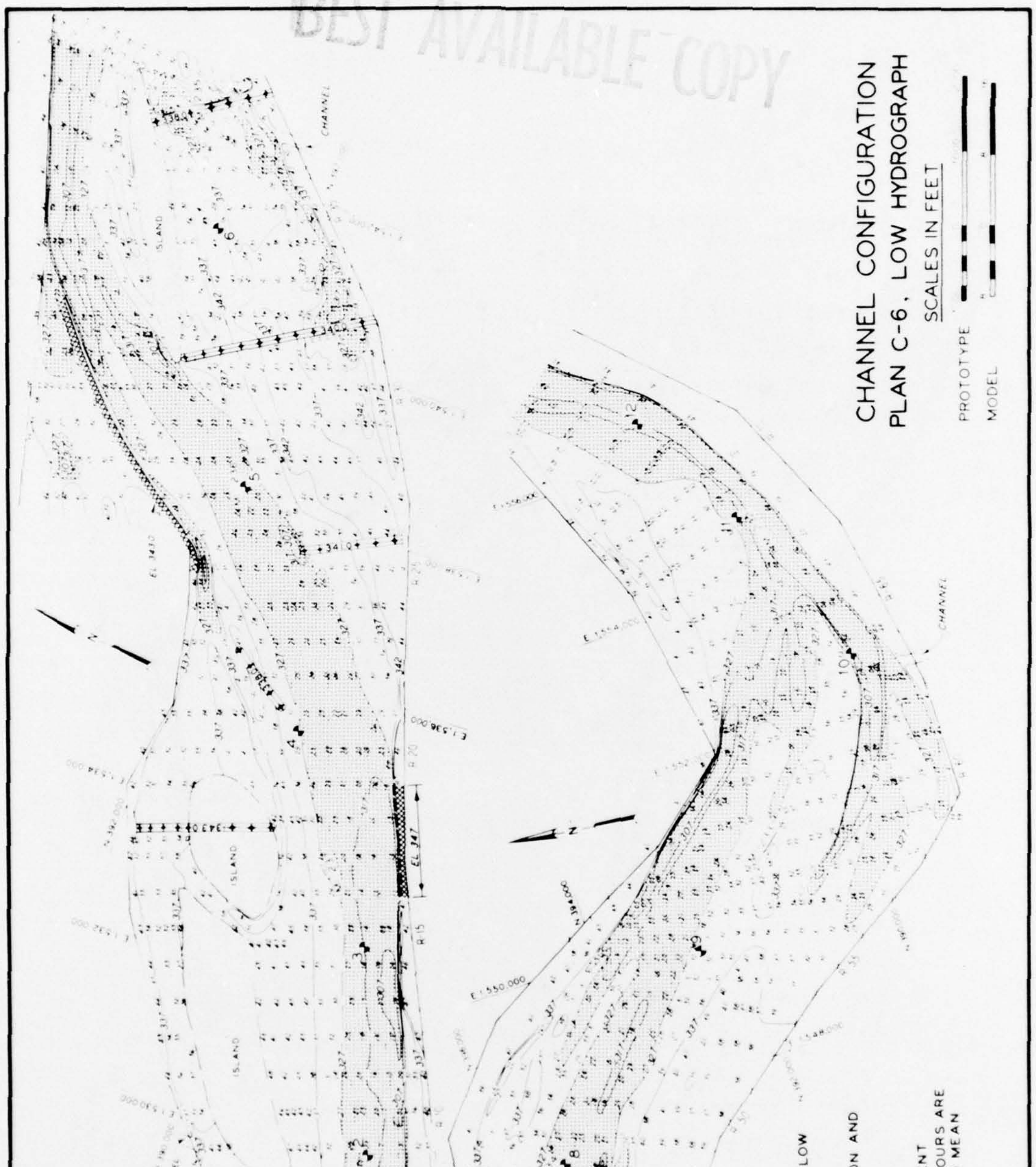
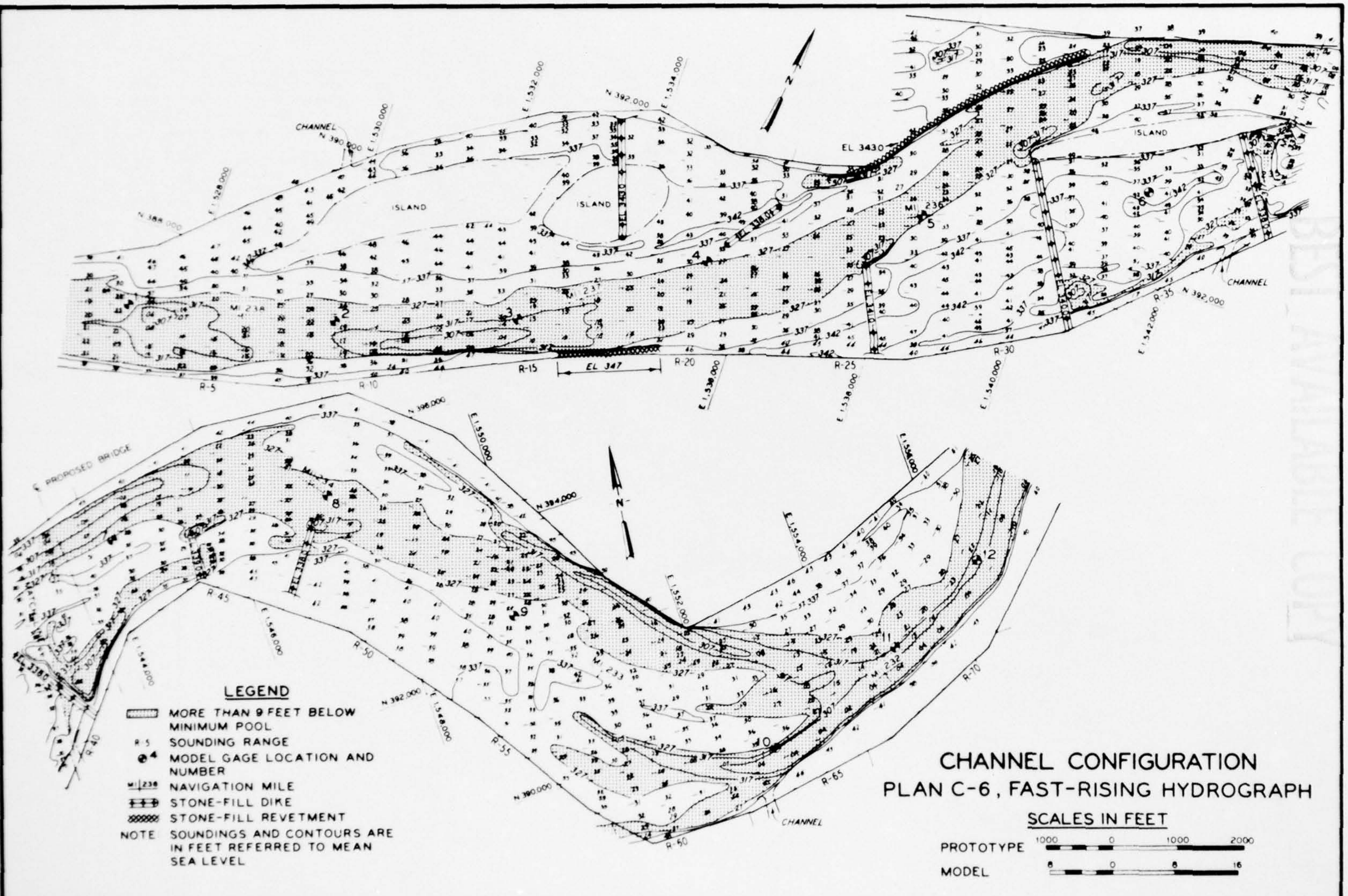

CHANNEL CONFIGURATION
PLAN C-6
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
ISLAND
ISLAND
ISLAND
ISLAND

PLATE 22


CHANNEL CONFIGURATION
PLAN C-6, LOW HYDROGRAPH
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE-FILL DIKE
STONE-FILL REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
ISLAND
CHANNEL
EL 347
EL 341.0
N



CHANNEL CONFIGURATION
PLAN C-6, FAST-RISING HYDROGRAPH

PLATE 24

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Foster, James E

Lake Dardanelle, Arkansas River; hydraulic model investigation, by James E. Foster [and] John J. Franco. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1977.

1 v. (various pagings) illus. 27 cm. (U. S. Waterways Experiment Station. Technical report H-77-4)

Prepared for U. S. Army Engineer District, Little Rock, Little Rock, Arkansas.

1. Arkansas River. 2. Channel improvements. 3. Channel stabilization. 4. Hydraulic models. 5. Lake Dardanelle. 6. Navigation channels. 7. River training structures. I. Franco, John J., joint author. II. U. S. Army Engineer District, Little Rock. (Series: U. S. Waterways Experiment Station, Vicksburg, Miss. Technical report H-77-4)

TA7.W34 no.H-77-4